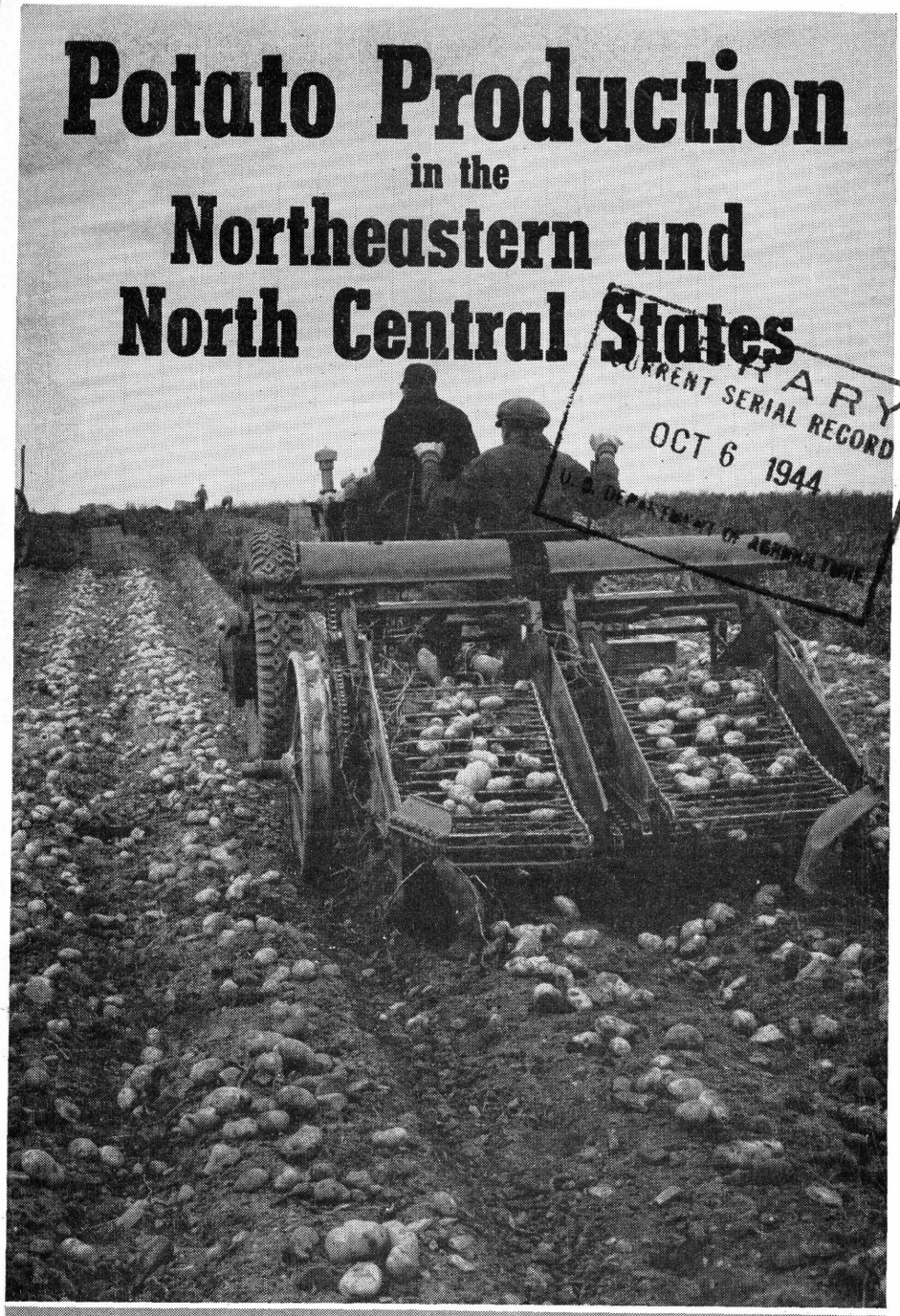
g84F
cop 2

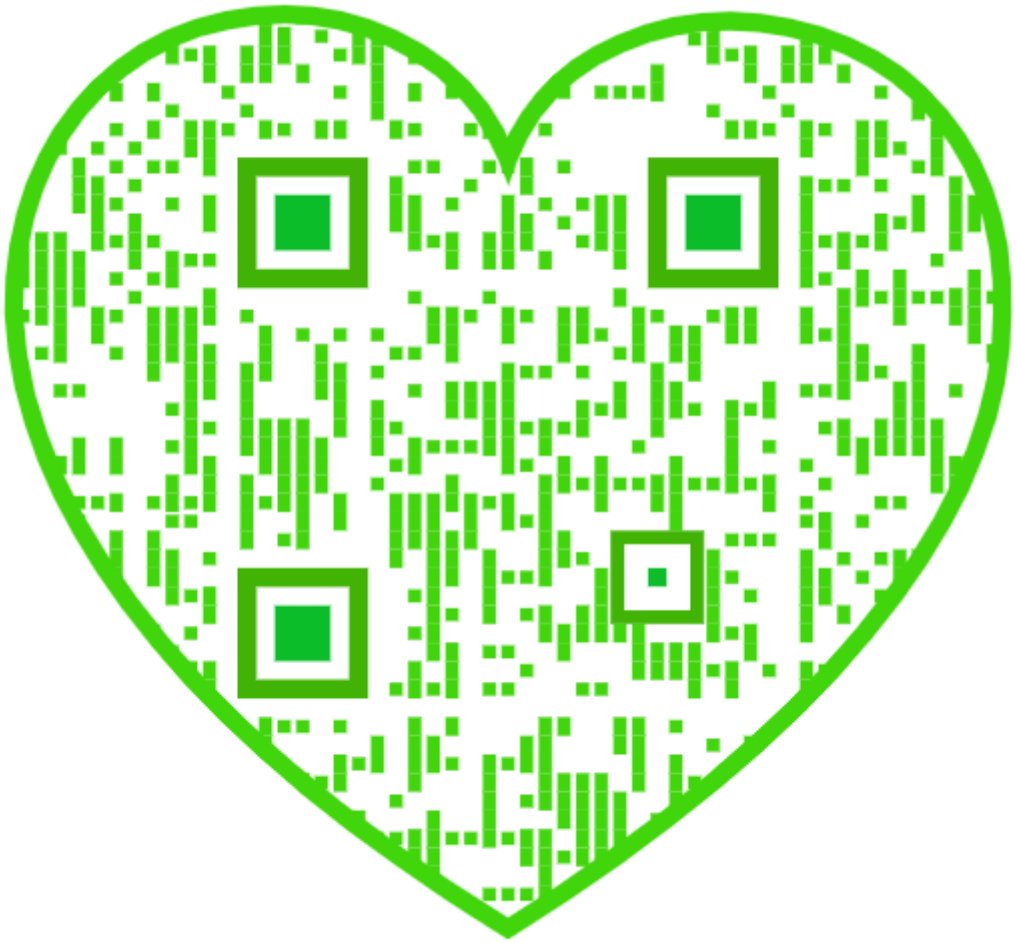
Potato Production in the Northeastern and North Central States



LIBRARY
CURRENT SERIAL RECORD
OCT 6 1944
U. S. DEPARTMENT OF AGRICULTURE

U. S. DEPARTMENT OF AGRICULTURE

Farmers' Bulletin No. 1958



POTATO PRODUCTION may be classed as early, intermediate, and late, depending upon the time of harvest. The late, or main, crop comprises about 80 percent of the total potato production of the United States. It is, therefore, of much greater economic importance than the early and intermediate crops combined. Approximately two-thirds of the late crop is stored in the fall and used as needed during the winter and spring.

The late crop is grown chiefly in the northern tier of States because of favorable climatic and soil conditions. The potato grows best where the mean temperatures during the summer are relatively low, generally not exceeding 70° F., and where ample moisture is available during the growing season. Many areas having suitable climatic and soil conditions are found north of the thirty-ninth parallel from Maine to the Pacific coast. These two factors largely determine the extent of the crop in any given State.

The late-crop potato industry in the States discussed in this bulletin is a highly specialized one. It is concerned with the production of potatoes for consumption, so-called table stock, and for seed stock. The production of maximum yields of good-quality table stock requires attention to essential details on the part of all growers; the production of healthy seed stock (certified) requires even greater attention if success is to be attained. Approximately 74 percent of the entire late crop of the United States is produced in the Northeastern and North Central States, and nearly 85 percent of the total certified-seed production can be credited to these States (1938–42 averages).

The purpose of this bulletin is to discuss various factors concerned with potato production, including the soil and its preparation; planting operations and subsequent cultural care of the crop; use of fertilizer, lime, and manure; varieties; care and treatment of seed tubers; spraying; harvesting; and storing.

This bulletin supersedes Farmers' Bulletin 1064, Production of Late or Main-Crop Potatoes.

Washington, D. C. Issued September, 1944

POTATO PRODUCTION IN THE NORTHEASTERN AND NORTH CENTRAL STATES

By P. M. LOMBARD, *associate horticulturist*, and BAILEY E. BROWN, *senior biochemist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

Contents

	Page
Statistics on the potato crop	1
Climatic and soil requirements	2
Crop rotation	3
Soil preparation and improvement	3
Plowing and fitting the land	3
Drainage and prevention of soil erosion	4
Building up the organic-matter content	5
Liming	6
Use of fertilizers	7
Varieties from which to choose	12
Older varieties in commercial production	12
Recently introduced varieties in commercial production	15
Importance of good seed stock	17
Treatment of seed potatoes with chemicals	18
Mercuric chloride	18
Acid-mercury dip	20
Organic mercury compounds	20
Yellow oxide of mercury	20
Cold formaldehyde	21
Hot formaldehyde	21
Cutting and healing seed potatoes	22
Planting	23
Use of planters	23
Time of planting	24
Rate of planting	25
Depth of planting	26
Cultivation	27
Late blight and its control	28
Insect enemies of potatoes	30
Colorado potato beetle	30
Potato flea beetle	31
Insect enemies of potatoes—Continued.	
Aphids	31
Seed-corn maggot	31
Potato leafhopper	32
Wireworms and other soil-infesting insects	32
Harvesting	33
Storage	34
Grading and marketing	36
Production centers and varieties grown in the several States	36
Connecticut	36
Illinois	37
Indiana	37
Iowa	37
Kansas	37
Maine	38
Massachusetts	38
Michigan	38
Minnesota	39
Missouri	39
New Hampshire	39
New Jersey	39
New York	40
North Dakota	40
Ohio	40
Pennsylvania	40
Rhode Island	41
South Dakota	41
Vermont	41
West Virginia	41
Wisconsin	42

STATISTICS ON THE POTATO CROP

POTATO crops are classified according to time of harvest as early, intermediate, and late. The late, or main, crop comprises about 80 percent of the total production. Approximately two-thirds of this is stored in the fall for use during the winter and spring. The late crop is grown chiefly in the northern tier of States, about 74 percent of it in the Northeastern and North Central States. Nearly 85 percent of the certified seed also is produced there.

The acreage harvested, production, yield per acre, and value of potatoes for the 21 States covered by this bulletin are given in table 1. It will be noted that 8 of these States produced on an average more than 10 million bushels for the period shown (1938–42) and that 1 other State averaged close to 10 million bushels. The acreages harvested, however, were great. From 1938 to 1942 Minnesota, with an average acreage harvested of 223,000 acres, led all other States in the group. It was followed by Michigan, New York, Wisconsin, Pennsylvania, Maine, North Dakota, and Ohio. The highest average acreage yield (258.0 bushels) for this period was obtained in Maine and the next highest (188.9 bushels) in Rhode Island.

TABLE 1.—*Acreage, production, yield per acre, price per bushel received by farmers, and value of potatoes in the 21 Northeastern and North Central States*

[5-year average, 1938–42 [1]]

State	Acreage harvested	Production	Acre yield	Average price per bushel received by farmers	Value
	Acres	*Bushels*	*Bushels*	*Cents*	*Dollars*
Maine	159,000	41,026,200	258.0	67.0	27,487,554
New York	200,800	27,489,200	136.9	82.6	22,706,079
Pennsylvania	174,000	20,895,200	120.1	89.8	18,763,890
Michigan	213,000	21,676,000	101.8	74.4	16,126,944
Wisconsin	179,200	14,818,000	82.7	66.2	9,809,516
Minnesota	223,000	19,776,600	88.7	61.2	12,103,279
North Dakota	149,000	15,539,000	104.3	52.6	8,173,514
South Dakota	30,000	2,076,000	69.2	67.0	1,390,920
West Virginia	32,600	3,356,400	103.0	92.0	3,087,888
Ohio	100,400	10,899,200	108.6	90.8	9,896,474
Indiana	49,800	5,213,000	104.7	88.6	4,618,718
Illinois	37,200	3,480,800	93.6	91.0	3,167,528
Iowa	56,600	5,818,400	102.8	80.0	4,654,720
New Hampshire	7,960	1,208,000	151.8	101.0	1,220,080
Vermont	13,460	1,773,400	131.8	99.8	1,769,853
Massachusetts	17,460	2,592,200	148.4	97.2	2,519,618
Rhode Island	4,460	842,800	188.9	95.2	802,346
Connecticut	16,420	2,874,000	175.0	97.6	2,805,024
New Jersey [2]	55,000	9,754,200	177.3	72.2	7,042,532
Kansas [2]	26,400	2,605,400	98.7	58.6	1,526,764
Missouri [2]	45,200	4,771,800	105.6	68.0	3,244,824

[1] The data were obtained from the revised figures of the Bureau of Agricultural Economics, Crop Reporting Board. Price per bushel in 1942 based on preliminary estimates.
[2] Classed as intermediate.

The annual value of the entire potato crop to growers varies with market conditions, but it is seldom less than $200,000,000 and when prices are normal it is nearer $300,000,000. From 1938 to 1942 the average value was $276,404,000. The value of the crop produced in the Northeastern and North Central States, about 59 percent of the total for this period, was approximately $163,000,000.

CLIMATIC AND SOIL REQUIREMENTS

The potato is a cool-climate plant which grows best in regions where the mean summer temperatures are relatively low, generally not exceeding 70° F., and where ample soil moisture is available during the growing season. Adequate moisture is especially important from the time tubers begin to form until slightly before harvest. In the region north of the thirty-ninth parallel from Maine to the Pacific coast are many areas where climatic and soil conditions, the two factors that largely determine the size of potato crops, are both suitable.

Among the best soils for potatoes are well-drained, sandy, gravelly, or shale loams and loams well-supplied with organic matter and available plant food. Part of the crop in Indiana, Iowa, Michigan, Minnesota, New York, Ohio, and Wisconsin is, however, produced on muck and peat. Such soils when well drained and properly fertilized are usually capable of producing good yields of high-quality potatoes. Heavier soils also are satisfactory provided they are adequately drained and their organic-matter content is maintained.

Certain soils should be avoided because they lack the necessary physical and chemical qualities or are infested with disease-producing organisms. Soils that are neutral or alkaline or that have produced many scabbed tubers are likely to produce diseased potatoes. Heavy, poorly drained clay and clay loam having tight subsoil and poor tilth are also likely to produce small crops of ill-shaped, poor-quality tubers.

Premature ripening of vines and consequent reduction in yield occur also on deep sandy soils that tend to blow, are subject to leaching, or possess low-water-holding capacity.

CROP ROTATION

No general recommendations can be made concerning the crops to be grown in rotation with potatoes, as these vary from place to place. In the New England States and in northern New York, Michigan, Wisconsin, and Minnesota a 3- to 5-year rotation is generally practiced; in this the clovers play an important part. In a 3-year rotation the potato crop is followed by grain in which clover and grass are seeded. The first cutting of clover is usually made into hay, whereas the second growth is turned under in the late summer or early autumn. In the corn country the order of rotation is usually clover, corn, and potatoes. Where alfalfa is grown a longer rotation is required, as it takes 2 years to get an alfalfa crop well established. For details as to the rotation best suited to local conditions consult the county agricultural agent.

SOIL PREPARATION AND IMPROVEMENT

PLOWING AND FITTING THE LAND

In general, land should be plowed in late summer or early fall for the late-potato crop (fig. 1). This holds for green-manure crops, such as the combination of oats, peas, and vetch, as well as for clover and alfalfa sod. Fall plowing facilitates decay of the sod and exposes the soil to the natural weathering processes during the winter months. The depth to plow depends largely on the depth of the surface soil and the character of the subsoil. A deep and fertile surface soil should be plowed to a depth of 10 inches or more; a shallow soil should not be

FIGURE 1.—Plowing under clover for the potato crop.

plowed more than an inch deeper than the plow depth. A 14-inch plow or larger is necessary to do a good job of plowing for potatoes. If much trash is to be turned under, plows with 16- and 18-inch bottoms and with a large clearance are needed. Fields with a decided slope should be strip-planted, and in most cases the plowing should be done in very late fall or in the spring to prevent undue erosion.

Fall-plowed land should be disked the following spring as soon as the land is dry enough to work (fig. 2). Disking pulverizes the soil, reduces large air pockets, and keeps the seedbed firm. On most potato soils the disk harrow should be followed by the spring-tooth harrow (fig. 3). It penetrates the soil deep enough to tear up clods, and the flexible teeth suffer little damage from stones or other obstructions. On some fields it may be necessary to use the spike-tooth harrow to break clods and level the ground. Such a harrow is also effective in covering small weeds.

DRAINAGE AND PREVENTION OF SOIL EROSION

Unless a soil is naturally drained, it should be drained by artificial means before potato growing is attempted. Excess water in the soil fills the pore spaces and excludes air, so necessary for bacterial decomposition of organic materials and for certain vital chemical reactions. Seed pieces often rot, and poor stands and reduced yields result. Root development is generally retarded. Poorly drained, heavy soils in particular are difficult to get in shape for planting and produce tubers of poor shape and quality.

Prevention of soil erosion cannot be too greatly stressed. Any

FIGURE 2.—Disking land in preparation for planting potatoes.

FIGURE 3.—The spring-tooth harrow in operation.

waste of topsoil ultimately means a serious loss of capital to the potato grower. Fortunately, in recent years Federal, State, and county agricultural agencies have combined in a Nation-wide battle against soil erosion.

The Soil Conservation Service, United States Department of Agriculture, is cooperating with farmers in all parts of the United States in demonstrating effective, practicable soil-conserving practices and methods. In checking erosion a complete diagnosis is essential before appropriate preventive remedies can be prescribed to correct the trouble. In view of the fact that erosion losses are due to diverse causes, it is obvious that no one remedy can be construed as a cure-all. For this reason, any potato grower who is confronted with an erosion problem should seek the advice of his local soil-conservation agency.

BUILDING UP THE ORGANIC-MATTER CONTENT

One of the most important soil problems in practically all potato regions, except those with muck and peat, is that of soil-organic matter. In regions with long seasons the decomposition of organic matter is almost continuous; in colder regions it is less rapid in summer and does not occur appreciably during the winter. An ample supply of decaying organic matter helps to keep the soil loose and mellow and thereby prevents packing. Organic matter also facilitates plowing and cultivating; it enables roots of potato plants to penetrate the soil more readily and retains rain water; it insures food energy for the growth of desirable soil micro-organisms; and it supplies plant food. These conditions enable potato tubers to develop better and to maintain their normal shape; shape is an important consideration in marketing the crop.

Each potato farm must ordinarily produce its own organic-matter supply. There are four general methods of getting organic matter into

the soil: (1) Adopting a suitable rotation in which a leguminous crop such as clover or alfalfa is grown; (2) growing and plowing under green-manure crops (including catch and cover crops), such as crimson clover, vetch, or a combination of peas and vetch, soybeans, cowpeas, rye, oats, barley, wheat, millet, Sudan grass, field corn, or other suitable crop plants; (3) applying barnyard manure; or (4) plowing under any other organic refuse that will increase the humus content of the soil.

Barnyard manures improve the physical condition of the soil, add plant food, and increase the bacterial activity. Manure should be carefully conserved so as to prevent as much as possible the loss of valuable nutrients. It should never be piled loosely in the open yard or allowed to accumulate under the eaves of the barn, because both methods permit leaching of valuable plant foods. The valuable constituents can be retained by keeping the manure moist and compact. If left in the open the pile should have a flat top and nearly straight sides. It should be kept moist throughout to avoid excessive heating, for, if the pile is allowed to dry out too much, firing results. To be used most efficiently for potatoes, manure, particularly when fresh, should be hauled directly to the field and spread uniformly on sod land before fall plowing. A manure spreader does the job very effectively. Succeeding rains will wash the soluble plant food into the soil. On sloping land the manure should be spread just before the plowing is done.

Light applications of manure are better than heavy ones. Make the manure cover as many acres as practicable; 60 tons is better on 10 acres than on 5. Generally it is considered a good practice to add 40 to 50 pounds of superphosphate to each ton of manure. However, where complete fertilizer is used in addition to the manure this treatment assumes less importance.

Fresh manure should not be applied just before the potato crop is planted, as it may produce a favorable environment for common scab development, particularly if the soil is not sufficiently acid in reaction. There is less danger on soils having a pH[1] of 5.0 than on those having a pH near 6.0. The best rule to follow in the use of fresh manure is to get it plowed under as soon as convenient, so that it will decay before the crop is planted.

LIMING

Liming is an important factor in potato production. When the soil is too acid the clover, or other soil-improvement crop, in the rotation begins to thin out and bare spots appear here and there in the fields. The question that concerns all potato growers, however, is how much lime to apply to help the clover but not increase the common scab on the potatoes. Where there is insufficient lime the clover suffers, but when there is too much lime common scab is apt to develop. Common scab is caused by a soil-borne organism (*Actinomyces scabies* (Thaxt.) Güssow). Its development is promoted by alkaline or mildly acid soil reactions. Increasing the soil acidity will usually check the development of the organism to a point where only clean tubers are obtained. The addition of too much lime to most soils, except very acid ones, generally favors its development. Too much acidity (below pH 5.0) is undesirable, and that above pH 5.5 may favor scab. The grower

[1] The pH value is the most common term now used to express the degree of acidity or alkalinity. It is simply a numerical expression denoting the acidity or alkalinity. A neutral soil has a pH value of 7; values above 7 denote alkalinity and those below 7, acidity. A soil with a pH value of 6.0 is mildly acid; one with a pH value of 5.0, strongly acid; and one with a pH value of 4.0, very strongly acid.

should obtain information about the lime requirement of his soil and about the local soil-testing services available.

Effective ways of using lime in potato rotations have been found, and as a result clover does well and common scab is held in check. In Aroostook County, Maine, potato growers have greatly increased their use of liming materials. Gardner, Beverly, and Reed,[2] writing on this subject, stated:

> Success in growing green manure crops is closely associated with an intelligent liming practice. In 1926, 200 tons of lime were known to have been applied to Aroostook soils; in 1930, 5,000 tons of lime were applied.[3]
>
> * * * * * * *
>
> In liming potato soils two points must be considered: (1) The effect upon the growth of clover or other green manure crops, and (2) the effect upon common scab infection. As a general rule, 1,000 pounds of a high analysis and finely ground limestone or hydrated lime will be found sufficient for a good catch of clover even when the soils are very strongly acid. When soils are less acid, smaller applications are recommended to avoid scab infection. Again, with a short rotation, the initial liming requirement will probably be somewhat greater than will successive requirements.
>
> One of several soil tests may be used to determine the acidity of a particular field. This indicated acidity serves as a basis in determining the proper amount of lime to apply. In general, it is not wise to lime potato soils which have an acidity above pH 5.2.

USE OF FERTILIZERS

Importance

Fertilizing potatoes is a highly important practice in all late-crop sections under consideration in this bulletin. As many fertilizer problems require first-hand knowledge about the soil and its previous treatment, only general information is presented. To obtain specific advice on kind, amount, ratio, placement, and home mixing of fertilizer, the grower should consult his county agent and State agricultural college.

The importance of plant nutrients in potato production has been shown by numerous comparisons of fertilized and unfertilized plots (fig. 4), as well as by the experience of potato growers. When a row, or a part of a row, is planted without fertilizer the effects are generally indicated by retarded, spindly growth and reduced yield. The growers of late-crop potatoes spend close to 20 million dollars annually for commercial fertilizer. This is a heavy financial outlay, and naturally the fertilizer should be used most efficiently.

Potato plants require an ample supply of plant nutrients to insure rapid, steady growth and proper tuber development. Moreover, these requirements must be met at the beginning of growth, as any delay in applying the fertilizer much beyond planting time might easily lead to a reduced yield. While there is a supply of available nutrients naturally present in the soil it must usually be supplemented with fertilizer to obtain maximum production. Decaying organic matter and barnyard manure also furnish some nutrients, but usually at too slow a rate to be adequate for the potato crop.

Kind and Amount

The kind and amount of fertilizer required for successful potato production will depend to a considerable extent on the kind of soil

[2] Gardner, A. K., Beverly, V. C., and Reed, D. W. Maine potatoes. Maine Agr. Col. Ext. Bul. 201, 35 pp., illus. 1931.

[3] According to information furnished later by Verne C. Beverly, county agent of Aroostook County, 14,526 tons of lime were used in 1940. This increasing use of lime has been due largely to the marked improvement in clover stands where lime was applied.

FIGURE 4.—Comparison of unfertilized (center) and fertilized rows (each side) of potatoes. Lighter-than-normal foliage, early blossoming, and early maturity are indications that no fertilizer was used.

and its state of fertility, on the available manure and its condition, and on the rotation practiced. It is generally conceded that fertilizer is most effective when an ample supply of moisture is present in the soil.

The most satisfactory fertilizer for the potato crop is one containing the three major plant-food constituents—nitrogen, phosphoric acid, and potash—in proper proportions. Complete fertilizer is generally used in late-crop potato sections, although sometimes nitrogen may not be considered necessary on muck and peat. In some sections where an ample supply of well-kept manure is used the only fertilizer material may be superphosphate. Although good yields may be obtained with manure reinforced with superphosphate, nevertheless it is usually conceded that a complete fertilizer gives better yields at less cost per bushel.

The nitrogen, phosphoric acid, potash ratio is important. No one ratio will fit all potato soils of the late-crop belt, but 1–2–1, 1–2–2, 1–2–3, 1–4–2, and 1–4–4 are the ones most widely recommended and used. Fertilizer analyses corresponding to these particular ratios are 5–10–5, 5–10–10, 4–8–12, 4–16–8, and 3–12–12 or 4–16–16. Double-strength fertilizers corresponding to these ratios contain twice as much nitrogen, phosphoric acid, and potash per ton. Other fertilizer analyses, such as 4–8–7, 4–8–8, 5–8–7, and 5–10–12, also are being used to a considerable extent.

The rate of fertilizer application varies from one potato-producing section to another, depending to a large extent on rainfall and soil factors. In sections of New England, notably in Aroostook County, Maine, growers customarily use a ton or more to the acre, the rate depending largely on the closeness of seed spacing and to some extent on the variety planted. Growers of certified seed are finding closer spacing an advantage, as it tends to produce tubers of more uniformly smaller size. A spacing of 8 inches between hills and 36

inches between rows means about 22,000 plants per acre, or about 50 percent more than at a 12-inch spacing. Naturally this means a greater competition for plant nutrients; hence some growers feel justified in applying 2,500 to 3,000 pounds of complete fertilizer to the acre.[4]

In New Jersey and on Long Island, N. Y., most growers in the highly commercial potato-producing districts use 1,800 to 2,000 pounds of fertilizers to the acre. Farmers in these districts having manure available may use less. In Pennsylvania, and to some extent in southern and western New York, less fertilizer is used, the rates ranging from 600 to 1,200 pounds per acre in accordance with the supply of manure.

Michigan growers average about 500 pounds to the acre for the lighter soils, with higher rates for the heavier types. Minnesota and Wisconsin growers are using more complete fertilizer than in years past, the rate of application depending on soil conditions. On the lighter sandy soils in sections where moisture is apt to be lacking, 500 pounds per acre is considered the maximum. On heavier soils, where growing conditions are more favorable, the rate of application of complete fertilizer ranges from 600 to 1,000 pounds per acre.

In all late-crop States growers will do well to follow the recommendations of the county agents and extension specialists relative to fertilizer practice.

High-Analysis Fertilizers

High-analysis fertilizers have come into much wider use in recent years, particularly in sections where heavy applications of fertilizer are made. In Maine in 1940 more than half of the plant food used was derived from double-strength fertilizer. The movement to do away with low-analysis fertilizers, which has had the support of agricultural agencies and the fertilizer industry, is rapidly gaining ground. Fertilizers containing less than 20 units[5] of nitrogen, phosphoric acid, and potash are not being recommended for producing the late crop. Those containing more than 20 units, such as 5–8–10, 5–10–10, 5–8–12, 8–16–14, 8–16–16, and 8–16–20 mixtures, are coming into wider use. Their advantage may be illustrated as follows. In some sections growers who were using a fertilizer with a 4–8–8 analysis have changed to one with a 5–10–10 analysis. Both of these have a 1–2–2 ratio, but 1,600 pounds of 5–10–10 is equivalent to 2,000 pounds of 4–8–8 in terms of plant food. A grower planting 50 acres and using 4–8–8 fertilizer at the rate of 2,000 pounds to the acre would need 50 tons, but if he were to use the 5–10–10 fertilizer he would need only 40 tons. With the 4–8–8 mixture there would be 1,000 100-pound bags to haul, store, and handle but with the 5–10–10, only 800. Growers appreciate the 20-percent reduction in weight, the smaller storage space required, the lower cost of transportation and bags, and the greater efficiency derived from labor. In terms of nitrogen, phosphoric acid, and potash, an application of 1,000 pounds per acre of 10–16–14 double-strength fertilizer is equivalent to 2,000 pounds of 5–8–7 single-strength fertilizer, and there are only half as many bags to handle.

Cooperative studies in Maine, New York, New Jersey, and Pennsylvania indicate that double-strength fertilizer when properly applied

[4] Equivalent to 1,250 to 1,500 pounds of double-strength fertilizer.

[5] Total percentage of nitrogen, phosphoric acid, and potash per ton. A unit is 1 percent of a ton.

is generally just as satisfactory as ordinary-strength fertilizer. Double-strength fertilizers with excellent drilling properties can be produced. This is important because any fertilizer mixture should be in good drillable condition at planting time to insure uniform distribution to each plant. Lumpy fertilizer generally has to be screened; screening is annoying and time-consuming.

Placement

Field studies comparing different methods of fertilizer placement have shown that the most effective method of applying fertilizer for potatoes is in a band on each side of the seed piece, about 2 inches away from the seed piece and on a level with or slightly below it (fig. 5). On sloping land, in order to prevent fertilizer from getting too close to the seed by shifting of the planter, it is recommended that the depth of fertilizer placement be about an inch below the seed-piece level.

When applied in the row and mixed with the soil, some of the fertilizer is apt to come in contact with the seed pieces and to result in retarded germination, weak plants, and greatly reduced yields. In Maine, for example, a 4-year average yield when fertilizer was placed at the side was 43 bushels per acre higher than when the fertilizer was mixed with soil in the row; in Michigan, 26 bushels; and in New Jersey, 24 bushels. Comparisons in other States gave results of the same order. The additional yields so obtained were not from any

FIGURE 5.—Comparison of different fertilizer placements in Ohio. *a*, Fertilizer applied in two bands 2 inches to each side of seed pieces; yield, 211.2 bushels per acre. *b*, Fertilizer in contact with seed pieces; yield, 108.7 bushels per acre. *c*, Fertilizer in band 2 inches under seed pieces; yield, 195.9 bushels per acre. Conducted cooperatively by Ohio Agricultural Experiment Station and the United States Department of Agriculture.

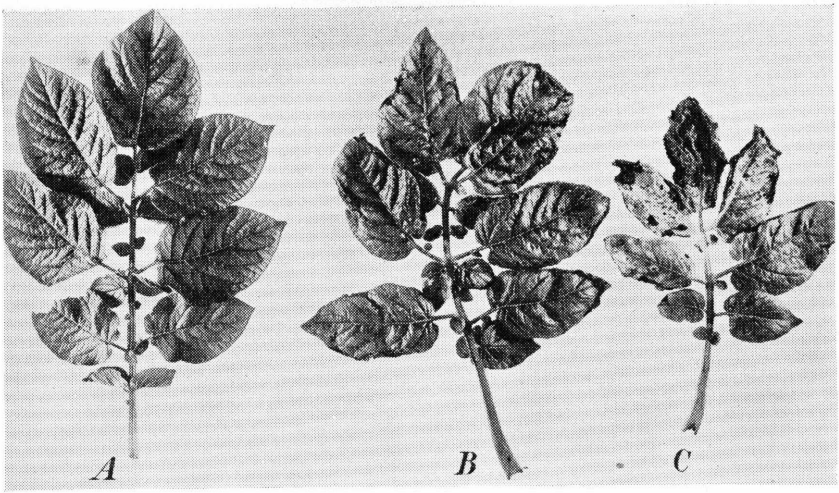


FIGURE 6.—Symptoms of magnesium deficiency on potato foliage: *A*, Normal leaf; *B*, leaf with intermediate symptoms (lighter-than-normal green color and preliminary break-down of tissue); *C*, leaf with advanced symptoms (dead tissue, pronounced loss of color, and brittleness).

change in the kind or quantity of fertilizer used but from a difference in the placement of the fertilizer.

Fertilizers should never come in direct contact with seed pieces or be deposited directly over them. Either position may mean a poor stand.

Avoidance of Nutrient Deficiencies

Magnesium, like nitrogen, phosphorus, and potassium, is an essential plant-food element. It is a component of chlorophyll, the green coloring matter of plants; if there is a lack of available magnesium in the soil the formation of chlorophyll is checked and normal growth activities are seriously disturbed. In severe cases of magnesium deficiency the entire plant is affected; the yellow-spotted leaves turn brown and frequently drop off. Fields so affected produce uniformly low yields. The symptoms of magnesium deficiency are shown in figure 6.

About 14 or 15 years ago magnesium-deficiency symptoms occurred in many potato fields along the Atlantic seaboard. Foliage of potato plants failed to develop the normal green color, at first being pale green and later changing to light yellow. The loss of green started at the tips and margins of the first leaves and progressed inward between the veins toward the centers of the leaflets. The foliage displayed a definite bulging between the veins and a characteristic thickening and brittleness.

The main factors causing the magnesium deficiency were heavy use of acid-forming fertilizers low in magnesium on potato soils already too acid, the leaching effect of prolonged rainfall before planting, and the lack of soil organic matter. Remedies included the addition of an available magnesium compound to the fertilizer, the use of potassium magnesium sulfate as a source of potash, an application of dolomitic limestone to the soil, and the use of dolomitic limestone in fertilizer.

Of the secondary elements only magnesium has been found definitely

lacking in potato soils, but other deficiencies are possible. Calcium and sulfur compounds are present in all soils, and appreciable amounts are added to the soil in fertilizer, particularly those containing ordinary superphosphate and ammonium sulfate. As double-strength fertilizer contains no ordinary superphosphate, it may become necessary to add calcium and sulfur compounds to prevent possible deficiencies of these elements. A deficiency of iron is only a remote possibility in potato soils having an acid reaction, as sufficient iron occurs in the soil solution to take care of normal growth requirements. Boron, manganese, and zinc have not been found deficient for potatoes in the late-crop areas under discussion. The boron requirement of the potato is relatively low; manganese and zinc, like iron, are available in acid soils in sufficient amounts. Copper has been found deficient on certain mucks and peats, but the amount added in sprays appears sufficient to prevent a deficiency of this element in most late-crop potato soils.

VARIETIES FROM WHICH TO CHOOSE

A relatively large number of varieties of potatoes are grown in the late- or main-crop sections of the United States. These differ in their time of maturity, yield, appearance, cooking and marketing qualities, and resistance to various destructive diseases and insects. Some varieties are susceptible to all of these, whereas others are resistant to one or more. All other characteristics being equal, resistance to even one destructive disease or insect makes a variety better than a susceptible one. A variety that is good in one section may be of little value in another. The grower is warned, therefore, against buying large quantities of high-priced seed stock of a recently introduced variety or of one reported superior in other localities until he learns whether it is adapted to his environmental conditions. The best procedure is for him to obtain the pertinent information from his county agent or State agricultural college or to test the variety himself on a limited scale.

OLDER VARIETIES IN COMMERCIAL PRODUCTION

For many years the principal commercial varieties of potatoes were those originated 50 to 75 years ago as a result of hybridization, as mutations or sports, or as chance seedlings. A number of these still in production in the Northeastern and North Central States are described briefly in this section for the benefit of those who wish to test or to grow them.

Triumph.—Early maturing. In this region grown chiefly in Wisconsin, Minnesota, and North Dakota. Adaptation similar to Irish Cobbler. Tubers round, blocky. Skin pink to deep red, depending on soil conditions. Eyes medium deep. Flowers pink. Susceptible to most diseases. Fairly mealy when cooked.

Early Ohio.—Early maturing, about 10 days later than Triumph. Grown commercially in the Red River Valley of Minnesota and North Dakota. Adapted to the Red River Valley gumbo soils and to the sandy-soil districts of Minnesota. Tubers ovoid to round, oblong, or cylindrical. Skin light pink to light red. Numerous moderately shallow eyes; lenticels prominent. Flowers white. Susceptible to virus diseases. Cooking quality good.

Irish Cobbler.—Early maturing. Grown in 18 of 21 States comprising the main-crop region. Adapted to muck and the lighter soils, preferring cool conditions and ample moisture supply. Tubers blocky, roundish (fig. 7). Skin glossy white. Eyes rather deep. Flowers lilac with white tips, bleaching nearly white under prolonged, intense heat. Susceptible to virus diseases and common scab.

Green Mountain.—Extensively grown in Maine, New York, Vermont, and Massachusetts. It is being replaced in some States by some of the newer varieties, chiefly Katahdin, Sebago, and Sequoia. Limited to cool and reasonably moist climate and to the lighter type of soils. Tubers oblong flattened (fig. 8). Flowers white. Susceptible to net necrosis and other virus diseases, stem-end browning, and common scab. Cooking quality usually good.

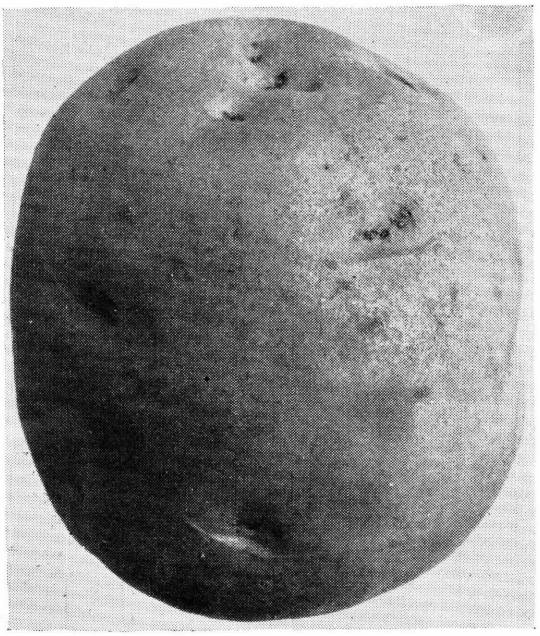
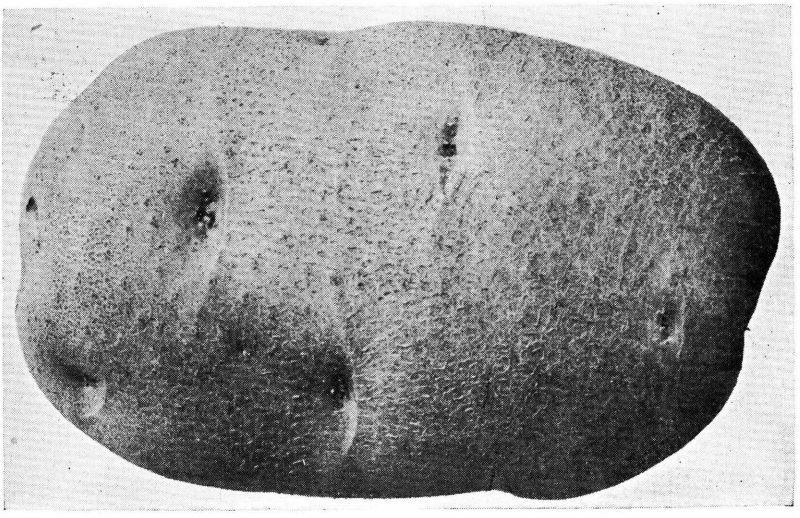


FIGURE 7.—A typical specimen of Irish Cobbler variety.

Rural New Yorker No. 2.—Late. Grown extensively in western and southern New York and in Pennsylvania, and also to some extent in certain districts of Wisconsin, Minnesota, and West Virginia. Being replaced in some districts by Katahdin, Chippewa, and Sebago. Well recommended for the heavier types of soil, doing well under adverse conditions. Tubers white, round, flattened to broadly roundish or oblong flattened (fig. 9). Eyes shallow. Flowers bluish-violet with white tips. Susceptible to mild mosaic and yellow dwarf. Well liked for its market and keeping qualities. Table quality good, but offset to some extent by blackening after cooking.

Russet Rural.—Late. Extensively grown in western New York and in Pennsylvania, Michigan, and Wisconsin. Acreage reported to be decreasing because of lack of consumer demand due to the dark color of skin, which is accentuated if Russet Rural is grown in the heavier types of soil. Being replaced to some

FIGURE 8.—A typical specimen of Green Mountain variety.



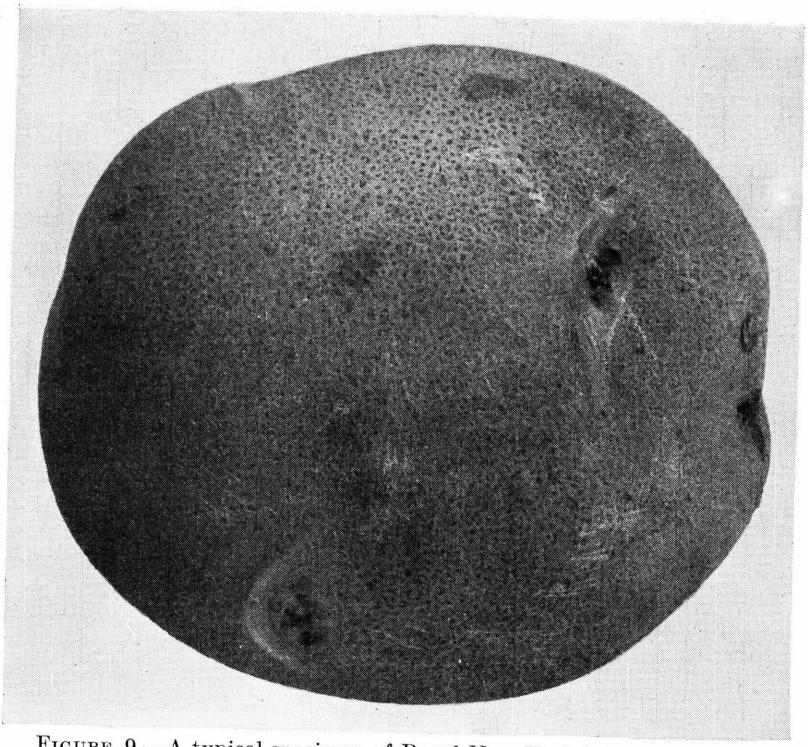


FIGURE 9.—A typical specimen of Rural New Yorker No. 2 variety.

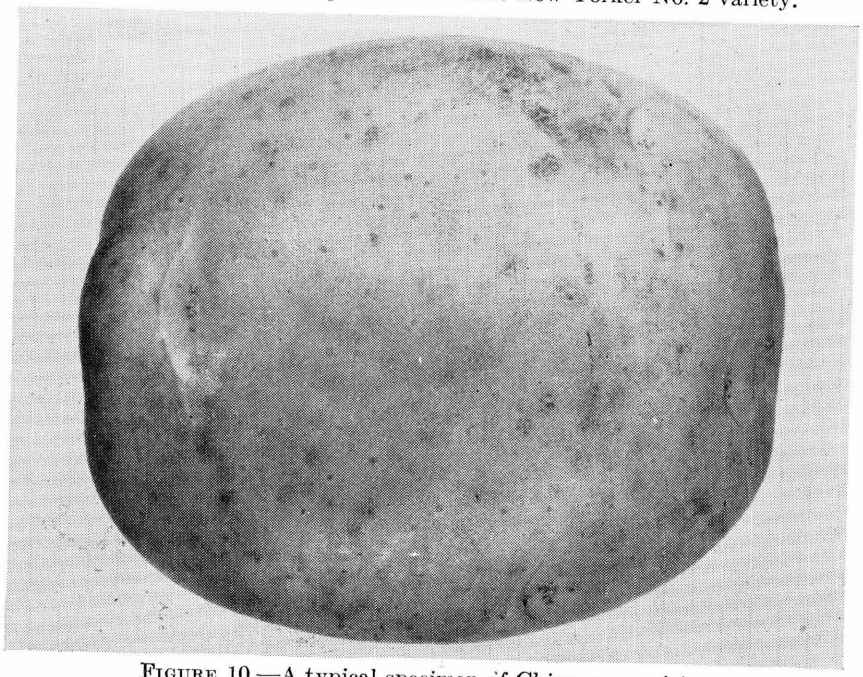


FIGURE 10.—A typical specimen of Chippewa variety.

extent by Katahdin, Chippewa, and Sebago. Adapted to regions subject to early drought. Similar to Rural New Yorker No. 2 except for color of skin, which is a deep russet with a much heavier netting, and far greater resistance to common scab. Keeps well.

RECENTLY INTRODUCED VARIETIES IN COMMERCIAL PRODUCTION

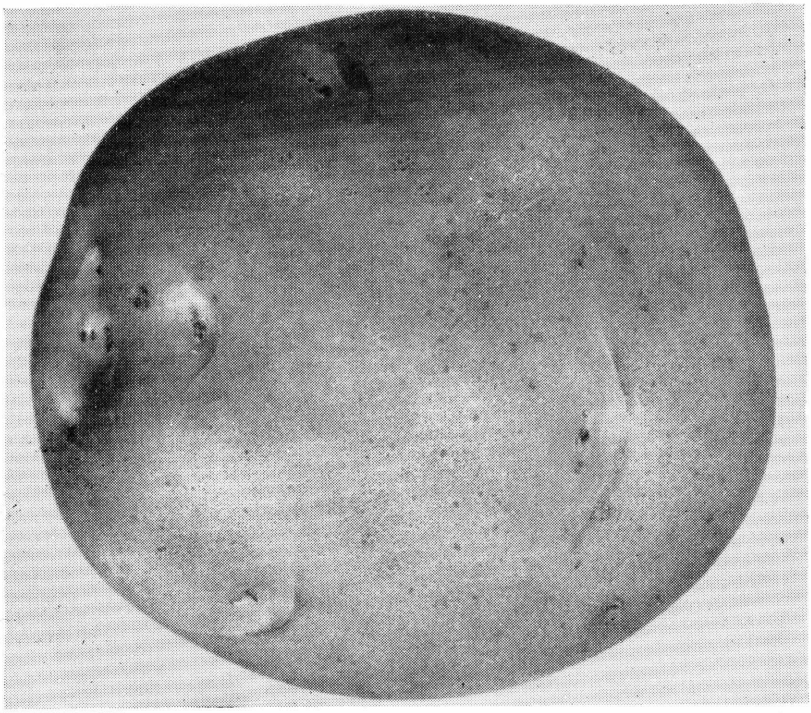
In recent years a number of new varieties have been originated and distributed by the national potato-breeding program [6] to growers in the districts where the late crop of potatoes is grown. These varieties are described so that readers will know the characteristics that make each suitable or unsuitable for his environment.

Earlaine.—Early. Adaptation somewhat limited; confined chiefly to sections outside the Southern and Midwestern States. Reported as being very promising in northern Maine and in certain counties in New York, where it produces good yields of smooth tubers, uniform in size and attractive in appearance. Tubers oblong, round, and flattened. Skin white. Eyes shallow. Flowers white. Highly resistant to mild mosaic under field conditions. Cooking quality fair.

Mesaba.—Early. Most extensively tested in Minnesota and Iowa. Adaptation, cooking quality, and disease resistance not widely determined. Tubers short, medium thick, and roundish. Skin relatively thick, self-colored, dark-creamy buff. Eyes shallow. Flesh white. Flowers pale lilac. Developed by the Minnesota Agricultural Experiment Station.

Warba.—Very early; earlier than either Irish Cobbler or Triumph. Wide range in adaptation; according to the Minnesota Agricultural Experiment Station, it appears to be especially adapted for an early-market potato, as well as for an early variety for the home garden. Tubers creamy white. Eyes pink, deep. Flowers light pink to lavender; sparse in number. Reported resistant to yellow dwarf and mild mosaic but susceptible to rugose mosaic and common scab. Cooking quality good.

FIGURE 11.—A typical specimen of Katahdin variety.



[6] Organized and conducted cooperatively by the Division of Fruit and Vegetable Crops and Diseases, more than 30 State agricultural experiment stations, and the Hawaii Agricultural Experiment Station.

Red Warba.—Sport of Warba, selected in Minnesota. Very early. Same general characteristics as Warba. Tubers red with splotches of white. Flowers light pink to lavender.

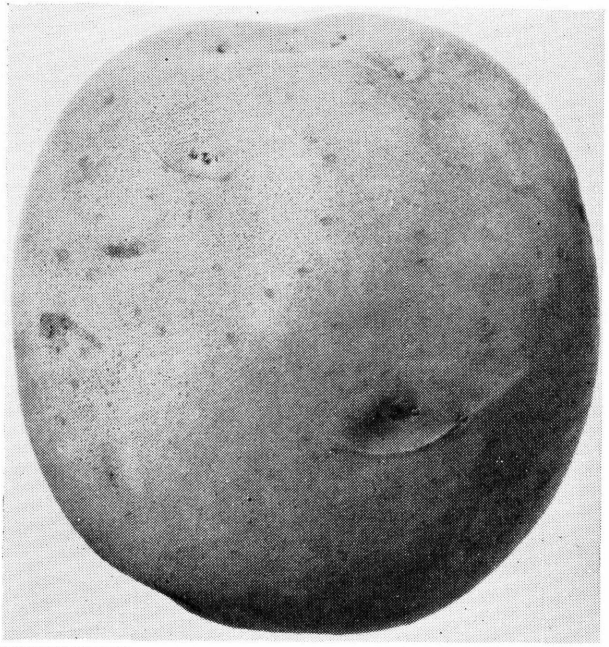
Chippewa.—Midseason, 10 to 15 days later than Irish Cobbler. Becoming very popular because of its wide adaptation; does well on peat or muck. Tubers (fig. 10) of attractive appearance. Shape oblong, flattened. Eyes shallow. Flowers lilac with white tips. Good yielder. Susceptible to leaf roll and spindle tuber, but to date no net necrosis found in tubers as a result of leaf roll infection; resistant to mild mosaic. Quality variable, depending on location; popular for French "fries" and potato chips.

Katahdin.—Late, maturing a little later than Green Mountain and at about the same time as Rural New Yorker No. 2. Adaptation wider than that of Chippewa. Sets fewer tubers than most other varieties. Tubers (fig. 11) glossy white, short elliptical to roundish, and generally smooth, even under unfavorable growing condition. Eyes shallow; few basal eyes. Flowers light lilac. Resistant to mild mosaic and yellow dwarf; but, in common with most standard varieties, not very resistant to leaf roll or spindle tuber. Cooking quality fair to good, depending on locality.

Houma.—Midseason. Acreage reported increasing. Adaptation and yield similar to Green Mountain. Tubers short and thick. Eyes shallow, tending to be deeper on bud end. Flowers white. Growth vigorous. Highly resistant to mild mosaic and reported also resistant to yellow dwarf in field tests in New York. Stores well. Cooking quality good—on a par with that of Green Mountain.

Pawnee.—Medium early. Performance good in Iowa, Maine, and Minnesota. Adaptation not widely determined. Tubers smooth, short elliptical to roundish, medium thick. Skin smooth, self-colored, varying from cream to dark-cream buff. Flesh white. Flowers petunia violet, somewhat similar to those of Rural New Yorker No. 2. Reported fairly resistant to common scab. Good keeping and cooking qualities. Developed by the United States Department of Agriculture in cooperation with the Colorado Agricultural Experiment Station.

FIGURE 12.—A typical specimen of Sebago variety.



Kasota.[7]—Midseason. Under Minnesota conditions maturing earlier than Chippewa and Pontiac; later than Triumph and Irish Cobbler. Adaptation not yet fully determined. Tubers broadly roundish, flattened, usually wider than long, medium thick. Skin smooth, medium red. Flesh white. Eyes shallow. Flowers light lavender. Cooking quality about same as that of Triumph, although rated slightly mealier in texture. Recently named and introduced jointly by Nebraska and Minnesota Agricultural Experiment Stations in cooperation with the United States Department of Agriculture.

[7] An Indian word referring to a clearing. Selected because it contains the last syllables of Nebraska and Minnesota.

Sebago.—Late. Wide adaptation to various environmental conditions; because of its lateness especially adapted to late-potato districts. Vigorously growing variety that produces comparatively high yields of tubers of high market quality. Tubers (fig. 12) white and thick. Eyes shallow. Flowers lilac. Moderately resistant to late blight and yellow dwarf and highly resistant to mild mosaic under field conditions. Must be well sprayed to prevent hopperburn. As susceptible to spindle tuber and leaf roll as any of the commonly grown commercial varieties. Good cooking quality if tubers are allowed to mature. Named and distributed in 1938; by 1943, 1,643,657 bushels of seed certified. Developed by the United States Department of Agriculture in cooperation with the Maine Agricultural Experiment Station.

Sequoia.—Late. Wide adaptation. Tubers large, oval flat, and often deeply recessed at bud end. Flowers white. Vine growth very vigorous. Yields exceptionally high. Tendency to produce oversize tubers may be checked by closer seed spacing. Although vines are somewhat resistant to drought, heat, and insect pests, adequate spraying is necessary. Tubers somewhat susceptible to common scab and late blight rot. Cooking quality good.

Pontiac.—Late. Adaptation not determined but acreage reported on the increase; does well on muck. Tubers somewhat similar to those of Triumph but possessing deeper red color and shallower eyes; less blocky. Yield of marketable tubers high. No marked resistance to common scab or virus diseases. In some trials in Michigan and Ohio it has proved to be more drought-resistant and freer from hollow heart and misshapen tubers than other varieties. Cooks white and fairly mealy, like Triumph.

Mohawk.—Midseason to late. Tubers elongated, thick, smooth, shallow-eyed, with excellent appearance. Flowers white with pink tips. Resembles Green Mountain, one of its parents. A good set and a high percentage of No. 1 tubers usually produced. Reported resistant to mild mosaic and to net necrosis due to leaf roll but susceptible to leaf roll in common with most varieties. No present evidence of resistance to common scab or late blight. Cooks mealy and bakes well. Introduced jointly by the New York Agricultural Experiment Station and the United States Department of Agriculture. Distributed to commercial potato growers in the fall of 1942.

IMPORTANCE OF GOOD SEED STOCK

The value of good seed stock has long been recognized as one of the important factors in potato production. Even the small grower realizes that the seed stock he uses must be reasonably free from virus and fungus diseases to enable him to harvest a maximum crop.

The certified seed-potato crop of 1942, the largest on record, was 20,475,067 bushels, as compared with 18,731,000 bushels in 1940, the previous high record, and 12,085,000 bushels for the 5-year (1934–38) average.[8] Certifying agencies of 25 States reported production of certified seed potatoes in 1942. Although only 11 State agencies reported certified seed production for the Northeastern and North Central States,[9] it is noteworthy that these States produced a total of 17,413,806 bushels of certified seed; also, even more noteworthy, that 3 of the 11 States—Maine, North Dakota, and Minnesota—produced an aggregate yield of 15,202,873 bushels, amounting to nearly 75 percent of the total certified seed production of the United States.

A part of the increase in production per acre in the United States during the last 20 years can be attributed to the use of certified seed. The average production of potatoes for the 10-year period 1911–20 was 106 bushels per acre; for the 10-year period 1921–30, 110.7 bushels; for the 10-year period 1931–40, 114.8 bushels; and for the 5-year period 1938–42, 128.8 bushels, with an all-time high of about 137 bushels per acre in 1942.

The shift of potato production to places such as Maine and Idaho,

[8] Crop Reporting Board, Bureau of Agricultural Economics, United States Department of Agriculture.
[9] Maine, North Dakota, Minnesota, New York, South Dakota, Michigan, Wisconsin, Pennsylvania, Vermont, New Hampshire, and New Jersey.

where per acre production is now much higher than in the older potato-producing States, has been an important factor in increased yields per acre for the United States as a whole. While the increasing use of certified seed has contributed to greater acre yields, other important factors, including a better knowledge and heavier use of fertilizers and their placement, more thorough spraying, introduction of disease-resistant and high-yielding varieties, and better all-round cultural care, have also contributed their influence toward increasing acre yields in the United States.

The certification requirements are now fairly uniform in the different States. In general, three inspections are made: The first is made as early as possible to identify diseases; the second, between the time of flowering and the time just before the vines mature; and the third, after the crop is graded. Some States have an extra inspection to detect ring rot (bacterial ring rot) either in the field at harvesttime or in the bin after the potatoes are stored. Certified seed costs more than the noncertified, but the extra cost is small considering the increased yields which may be expected from the use of good seed.

TREATMENT OF SEED POTATOES WITH CHEMICALS

The disinfection of seed potatoes prior to planting has been regarded in many late-crop areas as one of the necessary operations in potato production. The purpose of treating with various chemicals potato tubers intended for planting is to destroy the skin-borne organisms which cause such diseases as rhizoctonia canker and common scab. This is particularly true when new land is being brought under cultivation or when land long cultivated is not seriously infested with such organisms. It is obvious, for example, that the planting of untreated scabby tubers in new land would be inviting not only the production of scabby tubers but the introduction of the scab organism into the soil as well. The same also is true for *Rhizoctonia*. The value of seed treatment may be questioned, however, where soils are already heavily infested with the common scab organism or with *Rhizoctonia*. Where heavy scab infestation prevails, the grower would do well to consider whether it pays to try to grow potatoes. In mild cases of infestation, a combination of soil treatment with some acidifying material such as sulfur and the use of an acid-forming fertilizer are indicated. In any case a suitable rotation should be practiced.

Virus diseases and other diseases within the tuber are not affected by seed treatment. The fact that soils vary markedly from area to area in texture and structure, in cropping systems, in fertilizing treatment, in reaction, and in other factors makes it desirable for the grower to seek the advice of his extension service or agricultural experiment station on the questions involved in the treatment of seed potatoes. The effectiveness of a treatment depends on how carefully the operator follows instructions for the disinfectant used and on the maintenance of the strength of the solution if the mercuric chloride treatment is used.

MERCURIC CHLORIDE [10]

The effectiveness of mercuric chloride, or corrosive sublimate, as a disinfectant for potatoes has been known for a long time. The recommended strength for treating potatoes is 1 part of mercuric chloride

[10] Because of Government restrictions it may be difficult to purchase mercuric chloride for the duration.

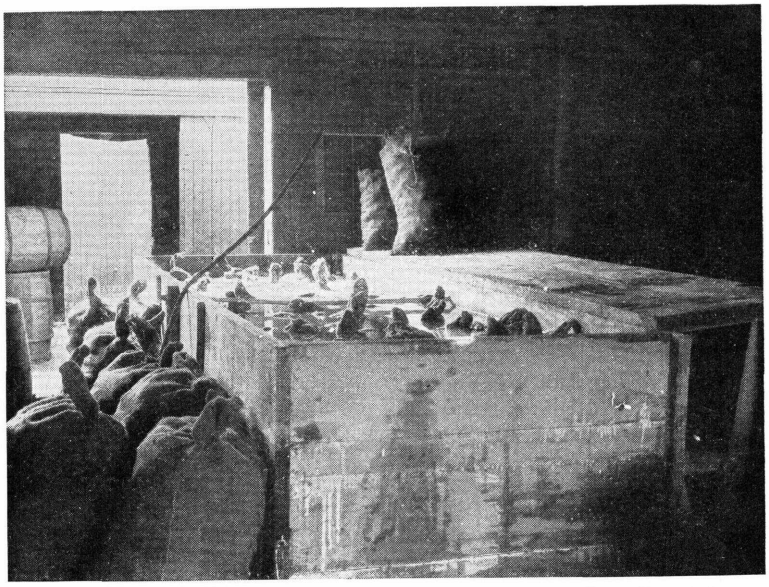


FIGURE 13.—Large tank commonly used for treatment of seed potatoes with mercuric chloride (corrosive sublimate).

in 1,000 parts of water (4 ounces in 30 gallons of water). Whole potatoes are treated for 30 minutes to 2 hours. Mercuric chloride goes into solution very slowly in cold water; so it should be dissolved in 2 or 3 quarts of warm water. The solution should be prepared and used in wooden, enamel, or concrete containers (fig. 13). As it decreases in strength with use, a correction should be made after each treatment. One-half ounce of the chemical should be added to the solution for every 4 or 5 bushels of potatoes treated 2 hours, or for the same quantity of potatoes treated 1½ hours three-eighths ounce should be added. Add enough water to bring the solution up to its original volume. Make a fresh solution after treating four lots of tubers. When potatoes are contaminated with soil or carry the sclerotia of *Rhizoctonia* the solution is more effective if the potatoes are kept wet for 20 to 24 hours before treatment. Do not store wet. Recent evidence indicates that the tubers of some of the recently introduced shallow-eyed varieties, such as Katahdin, Chippewa, and Earlaine, may be injured by this and other mercury treatments.

Mercuric chloride is a deadly poison, and great care must be taken in mixing and handling the solution to prevent any contact with the mouth, eyes, or nostrils. Rubber gloves should be worn to protect the hands and a rubber apron to protect the clothing. Unused solutions should be buried in the ground at least 1 foot deep. All vessels must be thoroughly cleaned before they are used again, and all clothing should be thoroughly cleaned. Any surplus chemical should be plainly labeled and stored out of the reach of children and animals. Sacks used for holding potatoes during treatment should be allowed to drain freely into a proper receptacle, and the drippings, if not usable again, should be buried in the ground at least 1 foot deep. Treated seed potatoes should be stored so there is no possibility of

livestock eating them and segregated so that they will not be mixed with potatoes intended for human consumption.

ACID-MERCURY DIP

The acid-mercury dip method is a short-time treatment, which reduces the time factor of the mercuric chloride method. It is considered to be the most effective control for surface-borne Rhizoctonia. The solution is made by dissolving 6 ounces of mercuric chloride in 1 quart of commercial hydrochloric (muriatic) acid, then adding 25 gallons of water in a wooden container and stirring. Do not put the solution in a metal container, as it causes corrosion. **The strong hydrochloric acid is very caustic and should be handled very carefully.** Treat only whole tubers by placing them in either a wire basket coated with asphalt paint or wooden crates and immersing them in the treating solution for 5 minutes. The tubers should be removed and dried quickly by being spread in a clean, shaded, thoroughly ventilated place; thereby possible injury is avoided. After being dried the tubers are ready to be cut and planted. From 20 to 30 bushels of tubers can be treated before a new solution is necessary.

In working with acid-mercury dip, use the same precautions as suggested for mercuric chloride (p. 19).

ORGANIC MERCURY COMPOUNDS

Organic mercury compounds are used as instantaneous dips as recommended by the manufacturer. These materials are poisonous but not corrosive and can be used in metal containers. Cut seed may be treated with them. After treatment both whole tubers and cut seed pieces should be thoroughly dried or planted immediately.

The same precautions should be exercised with organic mercury compounds as with mercuric chloride (p. 19).

YELLOW OXIDE OF MERCURY

Yellow oxide of mercury has been used for treating potatoes for several years, especially in New York. It is considered one of the best materials for an instantaneous dip, but it is not recommended for treating cut seed. It is as effective as mercuric chloride in the control of rhizoctonia canker. The best results are obtained if the tubers are planted within a few days after they are treated. If they are held more than 10 days before being planted, retarded vine growth and reduced yields will result. This treatment is not recommended in areas where the soil is alkaline enough to favor the development of common scab.

Yellow oxide of mercury is very poisonous, and the same precautions are recommended as for mercuric chloride (p. 19).

One pound of yellow oxide of mercury (technical grade) is added to 30 gallons of water in a wooden container or a metal container covered with a good coat of asphalt paint. The mixture should be stirred thoroughly with a wooden paddle until all the oxide is in suspension. A galvanized wire basket coated with asphalt paint will be found most useful in dipping the potatoes in the solution. The basket of potatoes should be immersed several times in the solution, being rotated at the same time to insure that all the surface of the tuber is wet and to help keep the solution well stirred. The treated potatoes are removed from the solution, drained, and emptied into a crate or open container

to dry. Several baskets should be available so that the dipping process can continue while the treated tubers are draining. It may be necessary to stir the solution at frequent intervals because the chemical must be in suspension to be effective. Because the mixture does not lose strength, it can be used as long as there is any solution left; 15 gallons will usually treat 100 or more bushels of potatoes. Normally the cost of the chemical is less than 2 cents for each bushel of potatoes treated.

COLD FORMALDEHYDE

Formaldehyde solution is prepared by adding 1 pint of commercial formalin to 30 gallons of water. It may be used for the control of common scab by soaking the uncut tubers in the solution for 2 hours. It is not effective in controlling rhizoctonia canker.

Formaldehyde solution is irritating to the skin when cold and will give off vapors irritating to the eyes and respiratory tract when heated. Rubber gloves fitting tightly at the wrist should be worn to prevent harm to the hands. If large quantities of seed are to be treated, a rubber or oilcloth apron should also be worn to protect the clothing. Surplus solution should be safely disposed of. Vessels and clothing should be thoroughly cleaned. If this operation is carried on in a building, a gas mask equipped with a suitable canister should be worn by each one in the room.

HOT FORMALDEHYDE

The hot-formaldehyde method has become very popular in some sections of the country where community or potato associations have equipment for handling large quantities of potatoes. Where such

FIGURE 14.—Small, hot-formaldehyde seed-treatment outfit suitable for use on the farm.

practice prevails, the potatoes are usually treated in sacks and allowed to dry in them. Small units of 1-bushel capacity are available (fig. 14). The solution is made by mixing 2 pints of formalin in 30 gallons of water heated to a temperature of 124° to 126° F. and held within these limits by steam or by means of a fire maintained beneath the tank. The tubers are then dipped for 4 minutes. A false floor in the tank is necessary to keep the tubers at the bottom from becoming overheated. The solution should not be warmer than 126°, because above this temperature injury to the sprouting of the potatoes results; nor should it be cooler than 124°, as it would then not control common scab or rhizoctonia canker if the tubers are dipped for only 4 minutes. To allow for condensation of water when live steam is used for heating, 0.9 pint of formalin should be added after every 50 bushels of tubers is treated. The solution does not lose its strength on standing if it is well covered, and it may be kept safely for a few days or weeks. The efficiency of this method is increased by covering the tubers with canvas or burlap for an hour after treatment.

A gas mask should be worn by all persons working with hot formaldehyde solution, both inside and outside of buildings. Other precautions should be taken as indicated for the cold-formaldehyde treatment (p. 21).

CUTTING AND HEALING SEED POTATOES

Most seed potatoes are cut by hand rather than with mechanical seed cutters, but the continued improvement of these seed-cutting devices is increasing their use in spite of the fact that the work they do is not so satisfactory as that done by hand. No mechanical seed-potato cutter yet devised is able to distinguish weak eyes, strong eyes, and no eyes at all. The mechanical seed cutter works satisfactorily when the tubers have been graded to a uniform size. The tendency among the potato growers today is to demand seed tubers of a more uniform size. Varieties such as Katahdin and Chippewa have few eyes on the basal half of the tuber, and when large tubers are used considerable waste results. Blocky seed pieces are desirable, as they can be handled to better advantage in the planter and are less liable to dry out or decay in the ground if weather conditions are unfavorable. The seed piece, in general, should weigh from 1½ to 2 ounces and should have from one to three eyes. The Katahdin variety invariably sets a small number of tubers per plant, and therefore each seed piece should have two or more eyes or the spacing in the row should be reduced.

The general practice among potato growers is to cut seed about the time it is needed for planting, usually having not more than a 2-days' supply cut in advance. Some growers who have large acreages and are limited in time and labor during the potato-planting season have found it more economical, as well as more convenient, to cut their seed potatoes in advance of the time for planting. When seed is cut for 10 days or more, but not exceeding 30 days, proper care should be taken to heal, or suberize,[11] the cut surfaces of the seed pieces.

Properly healed, or suberized, seed has several advantages over freshly cut seed. It can be cut before the rush of spring planting

[11] LOMBARD, P. M. SUBERIZATION OF POTATO SETS IN ITS RELATION TO STAND AND YIELD. Amer. Potato Jour. 14 (10): 311-318. 1937.

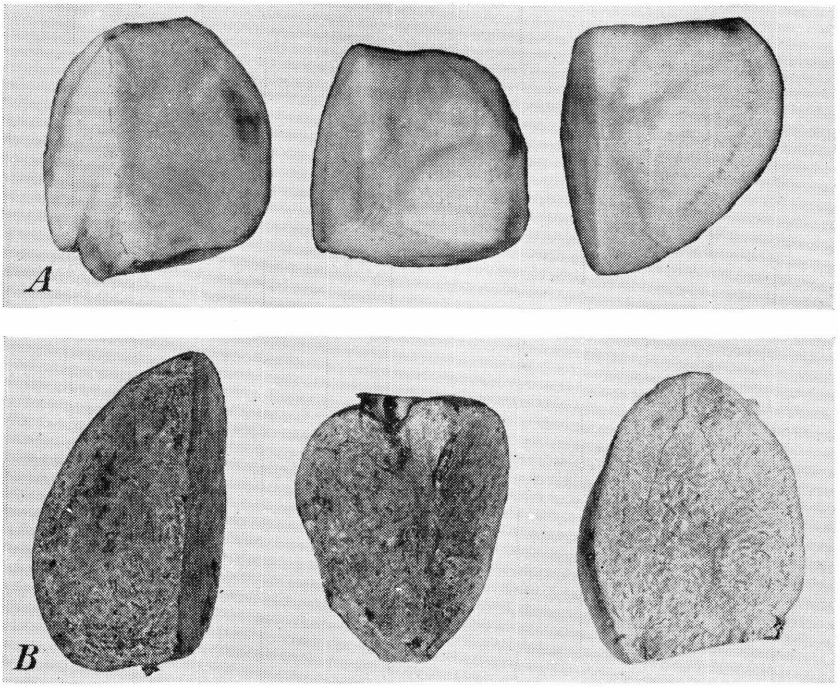


FIGURE 15.—Comparison of (*A*) freshly cut and (*B*) suberized, or corked-over, seed. Suberization protects seed pieces from the attack of decay organisms, from drying out, and from heating.

begins; it is less likely to shrivel if the soil is too dry at planting time or to rot if it is too wet after planting; and there is no danger of heating, which often happens in the case of freshly cut seed stored in barrels or bins. Many a poor stand has been attributed to seed of poor quality when it was the direct result of improper handling.

Suberization is best accomplished by holding the cut seed at a temperature of approximately 60° F. and a humidity of about 85 percent for a week or 10 days (fig. 15). The average potato grower can maintain these conditions by keeping a fire in the workroom where the seed is cut and by having a kettle of water boiling on the stove. Slatted crates are the best type of receptacle in which to suberize cut seed; suberizing is usually good at the temperature recommended if the crates of seed are covered with damp sacks. After the seed is thoroughly suberized, it can be stored in the potato house for at least 3 weeks, but it is not advisable to use seed that has been cut more than 30 days.

PLANTING

USE OF PLANTERS

The use of machine planters, either horse- or tractor-drawn, is general in the commercial areas (fig. 16). Hand planting is limited to gardens or tuber-unit seed plots of the commercial seed grower. The machine planters are of two general types, the picker and the assisted-feed. Two-, three-, and four-row planters of both types are now on

the market and in general use in some localities. Three- and four-row planters have met with favor only in those areas where the land is comparatively level and free from rocks.

The single-row picker-type planter, which is operated by but one man, is still the favorite machine for the potato grower with 50 acres or less and with only horsepower available. This type of planter is designed with eight arms on the picker wheel and two slender, sharp, steel prongs in each arm that pick up the seed pieces as the prongs pass through a compartment containing the seed. The picker arms are operated automatically by a cam, allowing the seed piece to fall into the seed tube. Large and small picks are used, and their location on the picker arm and their size depend on the size of seed used. This machine differs from the old-style picker-planter, which picked up the seed pieces with forms attached to the revolving disk. The seed pieces were stripped off the forks as they passed between two fingerlike attachments. The assisted-feed type of planter requires the assistance of another man in the rear to see that each pocket has one seed piece in the revolving, horizontal disk which discharges the seed piece from each pocket as it passes over the dropping tube. The revolving disk is fed from the seed hopper by a revolving cogged wheel. A much larger acreage can be planted in a day with the one-row picker-type planter than with the assisted-feed type, but usually the latter type insures a better stand of potatoes. The picker type of machine planting two or more rows requires a man in the rear to check on the seed, fertilizer, and performance of the pickers.

TIME OF PLANTING

The time of planting depends upon the prevailing climatic conditions. In the Northern States the season is relatively short, and, in general, potatoes should be planted as soon as the soil can be fitted.

FIGURE 16.—Planting potatoes, Aroostook County, Maine.

In Aroostook County, Maine, the entire growing season is required to mature a crop of potatoes.

The critical period in the life of the potato plant occurs when it is developing its tubers, and it is very essential that the climatic conditions should be as favorable as possible at this time. The yield is very materially lessened if a protracted spell of heat and drought occurs during this period. If the weather is cool and if there is adequate moisture and proper disease control a good yield is practically assured, provided the plants have been given proper cultural attention. In sections where the season is longer than is necessary to mature a crop, the problem is to select a planting date which will provide the most favorable climatic conditions during the period of tuber development.

RATE OF PLANTING

The spacing within the row and the distance between rows are determined in some localities by the natural fertility of the soil, its moisture-holding capacity, and the supply of available plant food that is to be applied to the crop. In the Northeastern States in the best potato soils the rows are sometimes spaced as close as 30 inches, although the average has been about 34, with a tendency in recent years to increase the spacing to 36 inches because of the use of motorized equipment.

Within the row the spacing averages about 12 inches, and the tendency is to narrow the distance to 10 or even 8 inches when such varieties as Sequoia and Katahdin are planted. These varieties set a small number of tubers, and closer spacing is necessary to prevent the development of a high percentage of oversize tubers. In Aroostook County, Maine, the combination of good seed, good cultural practices, and heavy fertilization produces a large percentage of oversize tubers, unless the spacing within the row is reduced below 12 inches. Close spacing in the row tends to reduce losses from hollow heart and oversize tubers and to increase the number of marketable tubers.

The quantity of seed to plant per acre depends not only on the spacing but also on the size of the seed pieces. Table 2 shows the number of seed pieces required for an acre when planted at different distances. An examination of the table shows that the closest spacing, 30 by 8 inches, would require 26,136 seed pieces to the acre, as compared with 14,520 for a spacing of 36 by 12 inches.

The general practice in the North is to use large seed pieces. On land well supplied with organic matter and available plant food and moisture, the use of large seed pieces or whole tubers from 1 to 2 ounces in weight will usually prove a profitable investment. The

TABLE 2.—*Seed pieces required to plant an acre of potatoes at different spacings*

Distance between rows	Pieces required for stated spacing distances					
	8 inches	10 inches	12 inches	14 inches	16 inches	18 inches
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
30 inches	26,136	20,909	17,424	14,935	13,068	11,616
32 inches	24,502	19,602	16,335	14,001	12,251	10,890
34 inches	23,061	18,449	15,374	13,178	11,531	10,249
36 inches	21,780	17,424	14,520	12,446	10,890	9,680

larger the seed piece the more seed required per acre. Table 3 has been prepared to afford a ready reference to the actual quantity of seed potatoes required to plant an acre with seed pieces of definite weights at a given distance apart.

TABLE 3.—*Seed potatoes required to plant an acre at different spacings with seed pieces of various sizes*

Spacing of rows and seed pieces	Quantity required with seed pieces of the average weight indicated				
	1 ounce	1¼ ounces	1½ ounces	1¾ ounces	2 ounces
	Bushels	*Bushels*	*Bushels*	*Bushels*	*Bushels*
Rows 30 inches apart:					
8-inch spacing	27.2	34.0	40.8	47.6	54.4
10-inch spacing	21.8	27.2	32.6	38.0	43.5
12-inch spacing	18.1	22.7	27.2	31.7	36.3
14-inch spacing	15.6	19.5	23.4	27.3	31.2
16-inch spacing	13.6	17.0	20.4	23.8	27.2
18-inch spacing	12.1	15.2	18.2	21.2	24.2
Rows 32 inches apart:					
8-inch spacing	25.5	31.1	38.2	44.6	51.0
10-inch spacing	20.4	25.5	30.6	35.7	40.8
12-inch spacing	17.1	21.3	25.6	29.9	34.1
14-inch spacing	14.5	18.2	21.8	25.4	29.1
16-inch spacing	12.8	16.0	19.2	22.4	25.6
18-inch spacing	11.3	14.2	17.0	19.8	22.7
Rows 34 inches apart:					
8-inch spacing	24.0	30.0	36.0	42.0	48.0
10-inch spacing	19.2	24.0	28.8	33.6	38.4
12-inch spacing	16.0	20.0	24.0	28.0	32.0
14-inch spacing	13.7	17.2	20.6	24.0	27.5
16-inch spacing	12.0	15.0	18.0	21.0	24.0
18-inch spacing	10.6	13.3	16.0	18.7	21.3
Rows 36 inches apart:					
8-inch spacing	22.7	28.3	34.0	39.7	45.3
10-inch spacing	18.1	22.7	27.2	31.7	36.3
12-inch spacing	15.1	18.9	22.6	26.4	30.1
14-inch spacing	12.9	16.2	19.4	22.6	25.9
16-inch spacing	11.3	14.2	17.0	19.8	22.7
18-inch spacing	10.1	12.7	15.4	17.7	20.3

As soil and weather conditions approach the optimum, it is usually the practice to increase the size of the seed piece and to use closer spacing. In general, the early-maturing varieties may be planted more closely than late-maturing sorts.

DEPTH OF PLANTING

No single depth of planting will give equally good results under all conditions. The determining factors are the character of soil, the season of planting, the cultural practice, and the climatic conditions that are likely to prevail during the growing season. Tuber-bearing stolons develop at the nodes on the stalk below the soil surface and above the seed piece. If the seed piece is planted shallow it is necessary to ridge the row after or during the early cultivations so that the plant can form stolons at some distance below the surface. On good soil and where ridging is practiced, the custom is to plant the seed piece 2 or 3 inches deep. The building up of the row is begun at the first cultivation, which usually occurs just before the plants break the ground, and is continued at each succeeding cultivation.

It is believed that good-quality potatoes develop under a fairly uniform temperature of 65° to 75° F. Tubers developing at a depth of 2½ to 5 inches are usually subject to these conditions. Great fluctuations in temperature are detrimental to the best development.

Seed pieces planted too shallow are subject to these fluctuations. If planted too deep, the tubers on the first nodes are undersize and of poor quality. The depth of the very early planting can be less than that of the late planting, because the ground is colder and the crop is less likely to suffer from temperature and moisture fluctuations. In fields where rhizoctonia canker is known to occur, the seed pieces should be planted shallow to insure quick emergence of the sprout above ground and thus free the plant from too early attack by the causal fungus (*Corticium solani* (Prill. and Del.) Bourd. and Galz.). After the plants are 6 to 8 inches tall the soil can gradually be built up around them. For level culture, the seed should be planted 3 to 4 inches below the field level with a covering of not more than 2 inches of soil over the seed piece. This is easily done by dropping the opening disks and the planter shoe and raising and adjusting the covering disks so that a little soil falls to the center, leaving a depression but throwing sufficient soil over the seed to cover it adequately.

CULTIVATION

The objectives in cultivation are to destroy weeds, aerate the soil, encourage root growth, and supply soil covering for the developing tubers. Cultivation of potatoes starts when the soil is being prepared for planting, for thorough preparation before planting is important. One harrowing before the potatoes come up is worth two afterwards. A good practice followed by some growers is to roll down the ridges left by the potato planter. This tends to compact the soil about the seed pieces, hastens germination, and makes the work of a smoothing harrow or weeder more effective. The use of weeders lengthwise on the row once or twice is very effective in controlling weeds after the potatoes are planted.

In general, but two systems, level and ridge cultivation, are practiced in the areas producing late potatoes. In the level system the weeder or smoothing harrow is usually used once or twice before the plants emerge. The teeth are angled back so as not to disturb the sprouted seed piece. Deep cultivation close to the rows follows as soon as the plants are high enough to distinguish the row. For each successive cultivation the side teeth are narrowed and raised, the wings being used to throw the soil around the plants to form a moderate ridge. Cultivation other than for weed control usually is not necessary and is likely to result in actual reduction in yield because of the destruction of roots and the increased loss of moisture.

In the ridge method, riding or walking cultivators are used to loosen the soil and to destroy weeds between the rows. Horse hoes with disks or wings are used after each cultivation to throw up earth and smother weeds along the row. With motorized equipment, cultivation and hilling are done in one operation. In the early cultivation the sprouting seed or young plants are buried once or twice to smother young weeds near the plants and protect the young potato plants from late frosts.

Cultivation should be discontinued as soon as the plants come into full bloom. If weeds are persistent after the plants have reached this stage and the rows are ridged, a spade with adjustable wings should be used to remove the weeds from the middle and the sides of the rows.

LATE BLIGHT AND ITS CONTROL [12]

Late blight is one of the most common diseases of potatoes in the Northern States, where it frequently causes an epidemic. It is caused by a fungus (*Phytophthora infestans* (Mont.) DBy.) that passes the winter in infected tubers. At low temperatures the causal organism is dormant, but growth continues in tubers stored in warm cellars. When an affected tuber is planted, the fungus may invade the sprout and often does so. Some of the infected sprouts are killed by the fungus before they break the ground; others may appear and continue to develop. If moist weather prevails for several days at a time, the fungus develops fruiting bodies on the infected stems above the soil. These appear as a white mildew. The spores of the fungus are produced in large numbers and are readily disseminated to nearby vines. Such plants may be the source of infection in potato fields.

Farmers should not dump waste or cull potatoes in piles. Plants that develop on these piles frequently develop late blight and from these spores are wind-blown to nearby fields before spraying or dusting begins. A potato farmer should consult his county agent regarding methods of handling so-called waste potatoes. By so doing he will protect not only his fields but his neighbors' fields as well.

Late blight appears in June, is rather prevalent in July, and vines that have not been sprayed may be dead by August. Other diseases of the potato are often mistaken for late blight. One of these is tipburn, which occurs commonly when hot, dry periods follow weather favorable for the growth of vines. Early blight is sometimes responsible for the death of the vines of early varieties and also occurs as a leaf spot on late varieties.

Late blight can be distinguished from the other diseases by the character of the infected area, which at first has a water-soaked

FIGURE 17.—Spraying potatoes wholesale, Tioga County, N. Y.

[12] For detailed discussions of this and other diseases of potatoes the reader is referred to U. S. Dept. Agr. Farmers' Bul. 1881, POTATO DISEASES AND THEIR CONTROL, and to the publications issued by various State agricultural colleges.

appearance but later turns dark brown and dries up. As long as the disease is progressing, however, the margin appears water-soaked. A white mildewy growth may be seen on the under side of the affected area, especially at the margin, and when the weather remains moist for several days the mildew may be seen also on the upper surface. This mildew alone distinguishes late blight from other troubles. The spots may occur anywhere on the vines.

In order to control late blight and other leaf diseases of the potato, spraying or dusting has to be practiced. Since late blight may attack the plants shortly after they are up, the first spray should be applied when the plants are about 6 inches high. Subsequent spraying should be done every 10 days until harvest. Thus far bordeaux mixture has given the best results (fig. 17). The materials required for making the 8–8–100 bordeaux mixture are 8 pounds of copper sulfate (blue vitriol), 8 pounds of hydrated lime, and 100 gallons of water.

Directions for preparing the spray mixture follow. Mixing is done at the point of water supply nearest the crop. The average potato grower has but one source of water, and at this point a storage tank holding several hundred gallons should be erected on an elevated platform with additional space for making the mixture. From the storage tank, water is run directly into the mixing barrels. A stock solution of lime is prepared by dumping 50 pounds of hydrated lime into a 50-gallon steel drum or barrel containing about a foot of water, stirring thoroughly, and then filling the barrel with water. A stock solution of copper sulfate is made by stirring 50 pounds of the powder into 50 gallons of water in a wooden barrel. Metal should not be used. If crystals are used they should be placed in a burlap bag and submerged near the top of the barrel for several hours or until the crystals are dissolved.

Each gallon of the stock solutions equals 1 pound of ingredient. To fill a 100-gallon spray tank with an 8–8–100 solution, first stir the contents of the lime barrel thoroughly and transfer 8 gallons to a 50-gallon barrel and fill with water; repeat the operation with copper sulfate in another barrel. The two solutions should then be run together into the spray tank. Where a power unit is available, run water directly into the spray tank, start the agitator, and add the copper sulfate. When the tank is two-thirds full, add the lime and keep the agitator going. Bordeaux mixture can be made by several methods. The main thing to keep in mind is not to pour two concentrated mixtures together.

About 50 gallons to the acre should be applied in the early sprays; the amount is increased to about 125 gallons in the late sprays.

Dusting with copper dusts has certain advantages over spraying, such as elimination of need for water and of long hauls for refilling, ease and simplicity of operating the duster, adaptation of dusters to hilly fields and soft land, faster operation of duster than sprayer. On the other hand, spray sticks to the vines longer than dusts, necessitating fewer applications; spraying can be done at any time during the day, whereas dusting can be done only in the early morning, in the evening, or at night because of requirements of low wind and damp foliage; and home-made bordeaux mixture is cheaper than the commercially prepared dusts.

INSECT ENEMIES OF POTATOES [13]

The common insect pests of potatoes in the Northeastern and North Central States are the Colorado potato beetle, the potato flea beetle, aphids, the potato leafhopper, and wireworms. The seed-corn maggot and white grubs are occasionally troublesome in some districts.

COLORADO POTATO BEETLE

The Colorado potato beetle (*Leptinotarsa decemlineata* (Say)) is one of the most widespread and destructive insect pests of potatoes in this country. The insect first appears in the spring in the form of the adult, or hard-shelled beetle, about two-fifths of an inch long. It is stout and round in general shape and light yellowish in general color, with 10 black stripes down its back. The female beetles lay their orange-red eggs in batches of 5 to 70 on the under side of the potato leaves. In 4 to 9 days these eggs hatch into small larvae. These larvae have soft bodies that range in color from lemon to reddish brown and are marked with 2 rows of black spots on each side. The head and legs are black. The larvae feed greedily and grow rapidly for approximately 2 weeks, during which time they devour large quantities of potato foliage. At the end of this period they reach full growth and are about three-fifths of an inch long. At this stage they drop from the plant and enter the soil, where they change to the inactive, or pupal, stage. They remain in this stage for a short time, the length of time depending upon the time of season and the locality. At the expiration of this period the adult, or beetle, emerges from the pupa and flies to a potato field to start a new generation of the pest. There may be 1 or 2 generations of this insect in any given locality each year, depending upon climatic conditions.

The Colorado potato beetle can be controlled with insecticides containing arsenicals or rotenone. For sprays, use 1 pound of paris green and 4 pounds of hydrated lime, or 4 pounds of calcium arsenate, or 4 pounds of lead arsenate, or 4 pounds of derris or cube root containing 4 to 5 percent of rotenone,[14] to each 100 gallons of water. If a bordeaux mixture is to be applied for the control of diseases, add the arsenicals, at the quantities stated, to each 100 gallons of the bordeaux mixture. For dusts, use at the rate of 1 pound of paris green or lead arsenate to 12 pounds of hydrated lime or equal parts of calcium arsenate and hydrated lime, or a dust mixture containing 0.75 percent of rotenone. Although the insecticides containing rotenone are effective in controlling the Colorado potato beetle, they are more expensive than the arsenicals.

In handling, mixing, and applying poisonous insecticides special care should be taken not to inhale excessive quantities at any time. Well-designed respirators affording protection to the entire face are available and should be used when such danger exists. After work with insecticides the hands or any exposed parts of the body should be washed thoroughly.

POTATO FLEA BEETLE

The potato flea beetle (*Epitrix cucumeris* (Harr.)) not only causes

[13] Prepared in the Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration.

[14] Wartime conditions have led to certain restrictions on the use of rotenone insecticides, and these restrictions are subject to change dependent upon the supply. For up-to-date information on the subject consult the War Food Administration, Office of Materials and Facilities, Washington, D. C.

reductions in the yield of potatoes in some sections of the North because of the feeding of the beetles on the foliage, but the attacks of the larvae on the potato tubers have resulted in producing potatoes of inferior quality. The adult of the flea beetle is about one-sixteenth of an inch long, is black in general appearance, and has yellow legs. When disturbed, it jumps quickly and may readily disappear from sight. It feeds on both surfaces of the leaves, producing numerous small holes. Severely injured leaves may dry up and fall from the plant. The immature form of the flea beetle is a slender, white, wormlike larva approximately one-fifth of an inch long. It feeds on the roots and tubers. On the tubers its feeding results in tiny tunnels near the surface of the tubers and pimplelike scars on the surface.

The most general control measure for the flea beetle is to spray thoroughly with bordeaux mixture to which is added calcium arsenate at the rate of 4 to 5 pounds for each 100 gallons of spray mixture. Use the larger amount of calcium arsenate for close seed spacing. It is particularly important to use the poison in the early sprays. If spray equipment is not available, dust with a mixture of calcium arsenate, monohydrated copper sulfate, and hydrated lime (25–20–55). Dusting is not so effective as spraying, however, for the control of this insect.

APHIDS

Several species of soft-bodied plant lice, or aphids, attack potato foliage. The potato aphid (*Macrosiphum (Illinoia) solanifolii* (Ashm.)) varies in color from green to pink and is often called the pink-and-green potato aphid. The green peach aphid (*Myzus persicae* (Sulz.)), which is also commonly found on potatoes, is green, as its name indicates. When abundant, these aphids reduce the yield of tubers by sucking the juices from the foliage.

Aphid infestations are difficult to control, but if control operations are begun at the early stages of the infestation by spraying with a mixture containing 1 pint of nicotine sulfate to 100 gallons of bordeaux mixture, good results can be obtained. Another effective spray for aphids on potatoes is prepared by adding 3 pounds of derris or cube root powder and 2 quarts of soybean oil to 100 gallons of bordeaux mixture. Substitute 100 gallons of water and 5 pounds of fish-oil soap for the bordeaux mixture if this mixture is not needed in either of these sprays for the control of diseases. Dust mixtures containing 0.75 percent of rotenone [15] are also effective against the aphids.

Nicotine sprays are poisonous and must be handled carefully

SEED-CORN MAGGOT

The seed-corn maggot (*Hylemya cilicrura* (Rond.)) is the immature, or maggot, form of a small fly that lays its eggs on soil and decaying vegetable matter. The small white maggots that emerge from the eggs feed on a wide range of substances, including both living and dead plant and animal life. Food preferences appear to be the sprouting seed and the seedlings of beans, corn, and peas. Their feeding on potato seed pieces in the soil is accompanied by decay, and results in the seed piece failing to sprout or in a stand of weak plants. Apparently the seed-corn maggot always begins feeding on the cut surface

[15] See footnote 14.

of the seed piece, as it has never been known to enter through the healthy skin of the tuber.

The best control for the seed-corn maggot is to allow the potato seed pieces to heal, or suberize, before they are planted. For further information on the control of the seed-corn maggot as a pest of potato seed pieces see Technical Bulletin 719, Prevention of Damage by the Seed-Corn Maggot to Potato Seed Pieces.

POTATO LEAFHOPPER

The potato leafhopper (*Empoasca fabae* (Harr.) is important as a pest of potatoes because its feeding on potatoes causes a destructive disease known as hopperburn. This disease begins with a yellowing of the leaf around the margin and tip, followed by a curling upward and rolling inward. The leaf changes in appearance from yellow to brown and then becomes dry and brittle. When the leafhopper infestation is heavy the entire plant may die prematurely.

The potato leafhopper is a small green insect, about one-eighth of an inch in length and wedge-shaped. It feeds from the under side of the leaves and sucks the juices of the plant. Leafhoppers are very active, and the first sign of infestation may be detected as one walks through the potato field and the small adults flit from plant to plant when disturbed. The lower surfaces of the leaves harbor the immature leafhoppers, which are similar in shape to the adults but are paler and do not have wings.

Leafhoppers and the resultant hopperburn can be controlled by spraying with bordeaux mixture or dusting with a dehydrated copper sulfate and lime mixture. The bordeaux mixture should be applied as soon as the adults appear, usually when the plants are 4 to 6 inches high, in areas where the insect is prevalent. Care should be taken to cover the under side of the leaves with the bordeaux mixture or with the dust mixture. Treatment should start with the first signs of the insect in the field; otherwise the bordeaux may not hold the pest in check.

WIREWORMS AND OTHER SOIL-INFESTING INSECTS

Potato tubers are often rendered unmarketable by small holes caused by the feeding of wireworms or by that of larvae of flea beetles, while larger scars may be caused by the feeding of white grubs. When the feeding scars are discovered, the insect that caused them is seldom to be found and it is difficult, therefore, to determine which one of a number of species is responsible. Wireworms make clean tunnels that are usually perpendicular to the surface of the tuber and are lined with a new growth of plant tissue. Flea beetles cause small pimplelike scars on the tuber and very small tunnels just below the skin. White grubs cause large holes that are usually irregular in shape and shallow.

No satisfactory methods have been found for the control of wireworms attacking potatoes in the northern potato-producing regions. Lands known to be infested by wireworms should be avoided for potato culture. The heaviest wireworm damage occurs usually in fields where potatoes are planted 2 or more years in succession. Fall plowing and crop rotation are suggested as means of reducing damage by wireworms and white grubs. Consult your local agricultural experiment station for help in solving your control problem.

HARVESTING

The date of digging potatoes should be influenced largely by the condition of the crop. The tops should be dead, and the tubers should be thoroughly hardened so that the skin will not peel easily or bruise. Only when the market conditions are extremely good and the crop is for immediate consumption should potatoes be harvested when the tops are still green. Otherwise spores of late blight still active in the living foliage may get on the tubers and cause rot in storage. To eliminate current-year infection by virus diseases, potatoes for seed are sometimes harvested early, usually late in July or early in August before the disease-carrying insects become numerous. Seed harvested at this time should be handled very carefully and stored for at least 2 weeks where the temperature range is 50° to 60° F.

A better practice than harvesting the tubers early, and one being increasingly used by growers in the certified-seed areas, is to pull the tops and leave the tubers in the ground for at least 2 weeks for the natural maturing process during which the skin becomes toughened. Still another method consists in the application of certain chemicals applied to the foliage by suitable means.[16] The latter method has been tried successfully in certain late-crop areas to kill the tops before too many oversize and hollow-hearted tubers develop; such tubers are especially apt to occur in seasons when growing conditions are at their best and killing frosts hold off late into the growing season. Growers have been finding that killing the green tops by means of chemicals not only arrests tuber development but makes digging and picking up the crop easier and faster and reduces late blight tuber infection to a considerable extent.

The harvesting season for most of the late crop of the North begins in September and extends into late October. The crop is harvested with the elevator type of digger hauled either by a pair of horses or by a tractor. The most satisfactory type of horse-drawn machine is equipped with a small gasoline engine mounted on the digger, which operates the carrier. The carrier in most cases should be continuous rather than have an extension elevator. The fall of the potatoes from the front elevator to the extension elevator accounts for a large amount of injury. The engine is equipped with an automatic clutch, which throws the engine out of gear when a rock or other obstruction is caught in the elevator. The speed of the engine can be regulated by the teamster. The tractor digger is equipped with a power take-off and a safety release clutch. Some two-row tractor diggers are used by large growers. These require an extra man in addition to the tractor driver.

Diggers should be set deep enough to provide sufficient earth to cushion the potatoes until they pass to the end of the elevator. On very light, dry soils where the soil falls through rapidly, the speed of the elevator should be reduced by change of gears, and the agitators bearing the elevator chain should be replaced with rollers. Methods of handling potatoes after they have been dug vary with the locality. In Maine the tubers are picked into baskets from which they are dumped into barrels and hauled to the storage house. The empty barrels are returned to the field. In most sections of the Northeast

[16] A number of commercial preparations for killing potato tops are on the market. Any potato grower interested in the subject should write to his State agricultural college for information and directions.

the potatoes are picked into slatted crates, hauled to the storage house, and either stored in the crates or dumped into bins. Handling in crates is preferable to that in barrels because less bruising results.[17] Careful handling of the crop at harvesttime will be found to pay good dividends.

STORAGE [18]

In the Northeastern and North Central States where potatoes are produced on a commercial scale the problem of storage is important, as it is practically impossible as well as economically undesirable to attempt to market the entire crop in the autumn immediately after it is harvested. To insure a uniform supply throughout the winter, storage must be provided on the farm or at the shipping station for 65 to 75 percent of the total crop. Commercial growers should make provision to store at least 75 percent of their crops, and often it would be convenient to store the entire crop. Types of storage places employed vary with the quantity to be stored and the length of the storage period. Filled pits or dwelling-house cellars may be used for small quantities or for emergency storage. However, where large quantities are to be stored or the potatoes are to be held late in the spring, common types of storage include root cellars and above-ground structures of various types (fig. 18). The cost of a conveniently arranged and well-insulated storage house will often be repaid by the saving of labor in handling the crop and the ability to hold potatoes with little loss until late in the spring. Each grower must determine for himself which of these types of storage house is within his means and best meets his requirements.

For information as to details of construction and matters pertaining to storage-house management see Farmers' Bulletin 847, Potato Storage and Storage Houses, and Technical Bulletin 615, Studies of Potato Storage Houses in Maine.[19]

The storage house or cellar should be in a well-drained location. It should be well insulated to keep the potatoes the from freezing and to control humidity. It is important that the ceiling or roof have enough insulation to prevent condensation of moisture, which may drop back on the tubers and predispose them to decay. The storage house should be so designed that potatoes can be put in and removed with a minimum of labor and of damage due to bruises and cuts. Daylight should be excluded as it causes greening, which injures the quality of table stock. In sections that have a relatively mild climate it is not usually advisable to store potatoes in bins more than 5 or 6 feet deep. When the weather is cool at digging time it may be safe to store potatoes 12 feet deep in the bins, but before spring the depth should be reduced if potatoes are to be held late.

A continuous space for air circulation should be provided between the bins and the outside walls and between the bottom of the bins and the main floor. The air circulation thus afforded, due to the warmer air rising in the storage and then passing down along the outside walls, will protect the potatoes from frost damage. At times a stove may be needed for additional protection. Provision should be made for the entrance of fresh air, and the intake should prefer-

[17] SCHRUMPF, W. E. THE EFFECT OF HANDLING METHODS ON QUALITY OF MAINE POTATOES. Maine Agr. Expt. Sta. Bul. 365, pp. 181–221, illus. 1933.

[18] Prepared by R. C. Wright, physiologist, Division of Fruit and Vegetable Crops and Diseases.

[19] Out of print, but may be consulted in libraries.

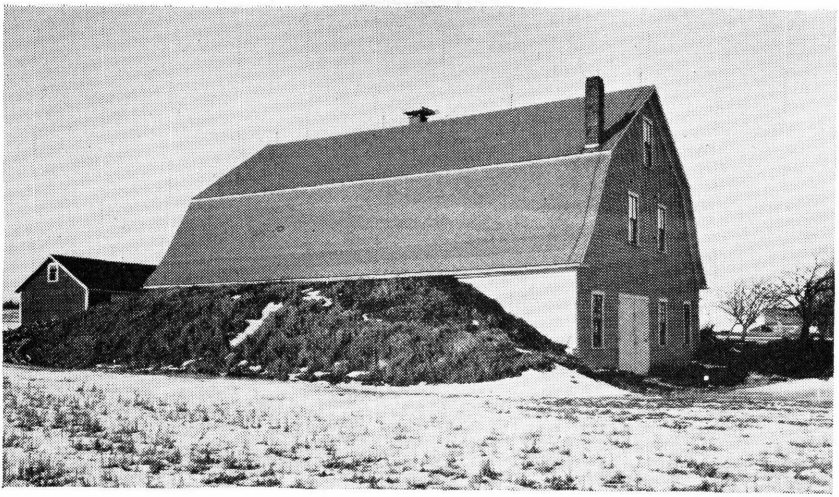


FIGURE 18.—A good type of potato storage house.

ably be near the stove so the air will be warmed and not injure the nearby potatoes. Ventilators must be provided for cooling the house when weather conditions require it. The manipulation of the ventilators is highly important and requires close attention.

The tubers should be dry and reasonably free from dirt when stored. If excess dirt accumulates within the bin or under the slatted floor, air circulation is hindered. All rotted, bruised, and badly cut tubers, as well as those that are badly scabbed, should be carefully culled before the crop is stored.

If ventilation is restricted during the first 2 or 3 weeks of storage so as to hold the potatoes at about 55° to 60° F. and in the high atmospheric humidity that prevails in a bin of freshly dug potatoes, the normal shrinkage can be reduced about 20 percent. This is due to the healing of cuts and injuries that occurs under favorable temperature and humidity conditions. Furthermore, potatoes receiving this preliminary treatment seem to retain better cooking quality than if the storage temperature is lowered immediately. A low temperature at the beginning of the storage period is not necessary because the tubers are then in a state of dormancy.

After this curing period, temperatures may be lowered; 38° F. is desirable for the storage of seed potatoes, since at this temperature they will not sprout; 40° or slightly higher is better for table stock.

Potatoes stored at 50° to 60° F. have better cooking quality, especially for making chips, because they contain less sugar than those stored at lower temperatures. In this higher temperature range, however, sprouting will occur in a shorter time. Although a limited amount of sprouting does not injure potatoes for food purposes, sprouted stock shrinks in weight and is difficult to market. Sprouting can be checked by lowering the storage temperature. Potatoes stored at 40° are acceptable for most purposes but not for chip making. Such potatoes, however, can usually be improved in cooking quality by being held at 60° or 70° for about 2 weeks before they are used. This permits some of the sweetness to disappear. At all times tubers should be protected from extremes of heat and cold.

The relative humidity should be kept at 85 to 90 percent.

Potatoes stored throughout the winter under conditions meeting the requirements suggested in the preceding paragraphs should not shrink more than 5 percent, and under especially good conditions they may shrink only 3 to 4 percent. Assuming that 5 percent represents the average loss under good storage conditions and 20 percent the loss under poor conditions, the actual loss sustained by the grower or dealer on 300,000 pounds of potatoes would in the one case be 15,000 pounds and in the other 60,000 pounds; or, at $1 per hundredweight, a loss of $150 would result under good and of $600 under poor storage conditions.

GRADING AND MARKETING

It is distinctly to the advantage of the potato grower, or for that matter of anyone offering potatoes for sale to the consuming public, to see that the potatoes present a good appearance. To accomplish this is good advertising for the potato industry. Potatoes having cuts, bruises, and insect or disease injuries neither sell well nor command a premium price. Such potatoes should be removed so that the consumer will not suffer loss in preparing them for the table and so that consumer prejudice will not develop against potatoes in general. Potatoes of undesirable size or shape and with excess dirt also should be removed before marketing is attempted. Only in this way can the individual grower hope to build up a reputation for good table stock and can any potato-producing region hope to establish a good reputation for its product. For complete information on marketing the late crop, see Circular 475, Marketing the Late Crop of Potatoes.

The United States Standards for Potatoes,[20] issued September 1941 by the United States Department of Agriculture and made effective June 1, 1942, fully describes potato grades as officially designated, the tolerances for defects pertaining thereto, and presents a definition of terms as used in the prescribed standards. Copies of the latest United States Standards for Potatoes may be obtained from the United States Department of Agriculture, Washington 25, D. C.

PRODUCTION CENTERS AND VARIETIES GROWN IN THE SEVERAL STATES

To assist the reader in acquiring general information about the potato industry in the different Northeastern and North Central States certain features relative to potato production in each State are discussed. Additional information may be obtained from the State college or agricultural experiment station.[21]

CONNECTICUT

Connecticut grows approximately 3,000,000 bushels of potatoes a year, chiefly of the Green Mountain variety. Most of these are grown commercially in the western to northwestern parts of Tolland County and in the eastern part of Hartford County. Recently there has been considerable development in the vicinity of Putnam in Windham County.

[20] See UNITED STATES STANDARDS FOR POTATOES, EFFECTIVE JUNE 1, 1942. U. S. Dept. Agr., Agr. Market. Admin. Serv. and Regulat. Announc. 151. 1941.

[21] The authors acknowledge the helpful cooperation of agricultural experiment station and extension service workers who furnished information on potato varieties, dates of planting, and other pertinent facts for the individual States.

Irish Cobbler is grown commercially to some extent in the New Haven-Bridgeport district and in parts of Fairfield and New Haven Counties. In the southern district potatoes are planted as early as April 15 to 20 and in the northern district between May 1 and 15.

ILLINOIS

In Illinois there are no districts in which a surplus of potatoes is produced. The districts of lowest production are usually near the centers of population and where soil conditions are not favorable for potato growing. Potato imports amount annually to about 25,000,000 bushels.

The bulk of the potato crop grown in Illinois is concentrated in the three northern tiers of counties and in three counties near St. Louis, Mo. Early varieties are chiefly Irish Cobbler and Triumph; later varieties are Rural New Yorker No. 2, Russet Rural, Katahdin, and Chippewa. The early varieties are planted in the latter part of March or the first part of April, depending on weather conditions. May 15 to June 1 is satisfactory for planting late potatoes.

INDIANA

The main commercial acreage of potatoes is grown on muck in northern Indiana. Planting begins there the first week in May. Irish Cobbler, Katahdin, and Chippewa make up the bulk of the potato acreage, although Sebago, White Rural, and Russet Rural are grown to some extent. Along the Ohio and Wabash Rivers, Irish Cobbler and Triumph are planted in March. The late varieties are planted in May and June. In July a second crop of Irish Cobblers is planted, but this commercial acreage is rapidly going out.

IOWA

Iowa does not produce enough potatoes to supply its own needs, although recently about 55,000 acres of potatoes, most of which are used on farms or sold on the local markets, have been grown. Because of high summer temperatures and unequal distribution of rainfall during the growing season, potato production in Iowa is less satisfactory than that of other crops, such as corn. Irish Cobbler and Chippewa are considered the best varieties for Iowa conditions. Early Ohio is grown to some extent, but it is likely to have knobby tubers and growth cracks and does not yield as well under adverse weather conditions as Irish Cobbler does. Rurals may be grown with fair success, but they mature late and do not produce satisfactory yields. Pontiac has shown considerable promise in a 2-year test conducted by the Iowa Agricultural Experiment Station.

Potatoes are planted in southern Iowa about April 1 and in northern Iowa from April 15 to 20. On peat or muck in northern Iowa, where most of the commercial crop is grown, the planting date usually ranges from April 20 to 25.

KANSAS

The district where potatoes are grown commercially in Kansas, one of the intermediate potato States, is the Kaw Valley, including Wyandotte, Johnson, Leavenworth, Douglas, Jefferson, Shawnee, Pottawatomie, and Wabaunsee Counties. The main commercial crop is

planted between March 20 and 25. Very few potatoes are grown commercially as a late crop, but when so grown they are planted more in late June or early July. The principal variety of potato in Kansas is Irish Cobbler, followed closely by Triumph, which is grown for the late crop.

MAINE

Maine has led the United States in potato production for the past 20 years. All but approximately 15 percent of the crop is produced in Aroostook County, the northernmost county in the State. The farming land in Aroostook County lies in a narrow belt, from one to three townships wide, along the eastern and northeastern part of the State. The temperature throughout the growing period is very favorable for potato production. During the growing period 12 to 18 inches of rainfall is essential for good yields. Planting in Aroostook County begins as soon as the soil can be fitted, and the planting season ranges from about May 10 to the end of May or early June. Planting in the southern part of the State begins 10 days to 2 weeks earlier.

Irish Cobbler is the chief early variety of commercial importance in Maine. Triumph and Spaulding Rose are on their way out, and the acreage of Green Mountain is on the decrease. The older varieties are being replaced by Katahdin, Chippewa, Sebago, and Houma.

MASSACHUSETTS

Massachusetts produces about one-fifth of the potatoes required for consumption in the State. Soil and climatic conditions are not particularly favorable for large potato yields, and costs of production are apt to run too high. Other crops can be produced at a better profit.

Irish Cobbler is the principal early variety. Along the Narragansett Basin planting begins in early April, progresses to the Connecticut Valley and other areas of low altitude, and ends in the hill districts of western Massachusetts where June planting predominates. Green Mountain is the main variety for a late crop, with Chippewa gaining acreage each year.

MICHIGAN

Michigan is divided commercially into four districts: (1) The eastern district, which produces largely table stock, is located in the east-central part of the State in Oakland, Lapeer, and adjoining counties; (2) the western district, also a table-stock-producing district, extends north from Kent and Montcalm Counties and includes Wexford and Missaukee Counties; (3) the northern district, which comprises the northern counties of the Lower Peninsula; and (4) the Upper Peninsula. Certified seed is produced largely in the northern district. Early planting is heaviest about May 20 and late planting from June 1 to 5, depending on the district to be planted. The growing season in the eastern district varies from 140 to 155 days and in the western and northern districts from 130 to 150 days, respectively. A large part of the Upper Peninsula has a growing season of 90 to 130 days, with 140 to 150 days prevailing along the lake shores.

The best late varieties grown in Michigan are White Rural, Russet Rural, and Green Mountain; medium early, Chippewa and Katahdin; and early, Irish Cobbler.

MINNESOTA

Minnesota is divided into four potato-growing districts: (1) The Red River Valley, located in the northwestern part of the State, where both table stock and certified seed of Irish Cobbler, Early Ohio, and Triumph are grown; (2) the sand-land district comprising 12 to 15 counties north and northwest of the Twin Cities and containing about 500,000 acres of high-lime peat, where Irish Cobbler, Triumph, and Russet Burbank are grown; (3) east of the Red River Valley and north of the sand-land district in the Arrowhead country (soils vary from light sands to heavy clays) Triumph, Irish Cobbler, Green Mountain, and Russet Burbank varieties are reported as doing especially well; and (4) the southern district, where potatoes are grown mostly for home use. Potatoes are grown commercially, however, in the Freeborn County bogs, the Irish Cobbler being grown almost exclusively. Rural New Yorker No. 2 does best for this district as a whole. In the southern half of the State planting begins about April 15; in the peat bogs about May 1; and in the northern half of the State about May 15, continuing through the first week in June.

MISSOURI

Soil and climatic conditions in Missouri, one of the intermediate potato States, are reported as not being particularly favorable for growing late-crop potatoes. The Irish Cobbler is the principal variety grown. Other varieties are Triumph and Red Warba.

Potatoes are planted as soon as the land can be prepared in the spring; the time varies from March 1 in southern Missouri to April 1 in the northern part of the State. Most of the commercial acreage is in central Missouri and on the Missouri River bottom land, where planting occurs about March 20.

NEW HAMPSHIRE

New Hampshire could profitably grow enough potatoes to supply all her needs, yet a considerable quantity is shipped in every year. The principal varieties grown in New Hampshire are Irish Cobbler for the early crop and Green Mountain for a late crop. In southern New Hampshire the planting dates range from April 20 to May 20 and in the northern counties from May 1 to May 20. Late plantings range from May 5 to June 15 in the southern part of the State and from May 10 to June 5 in the northern part.

NEW JERSEY

New Jersey is classified as one of the intermediate potato States. Early potatoes, or those harvested before July 10 to 15, are planted between March 15 and April 1. Late varieties are planted in the northern counties from May 1 to 15. Approximately 80 to 85 percent of the New Jersey crop is planted between March 25 and May 1. The bulk of the crop is produced in the three central counties: Monmouth, Middlesex, and Mercer. Burlington, Cumberland, and Salem Counties also grow considerable acreages. The principal varieties grown are Katahdin, 45 to 50 percent; Irish Cobbler, 30 to 35 percent; Chippewa, 15 to 20 percent; Green Mountain, 3 to 4 percent; and other varieties, 2 to 3 percent.

NEW YORK

In the main-crop sections under consideration, New York ranks next to Maine in potato production. The three districts of most extensive production are the following: (1) Western New York, including Steuben, Monroe, Erie, Wyoming, Onondaga, Allegany, Genesee, Ontario, and Livingston Counties. Potatoes fit well in the rotation in western New York, and although 10 acres is about the average per farm, the total production is large. Several varieties including the Rural New Yorker No. 2 (Smooth Rural), the Russet Rural, Irish Cobbler, Green Mountain, Katahdin, Chippewa, and Sebago are grown. Planting begins in late May and extends into June. (2) Northern New York, including Franklin and Clinton Counties. Because of favorable climatic and soil conditions these counties produce excellent crops of potatoes. Considerable certified seed is produced in northern New York. The two principal varieties in this district are Green Mountain and Irish Cobbler. The planting date is a little later than in western New York. (3) Long Island, including Suffolk and Nassau Counties. Long Island has a longer season and a better type of potato soil, and production is more highly developed than elsewhere in the State. Direct transportation facilities are available into New York City. Suffolk is the heaviest potato-producing county in New York. Green Mountain and Irish Cobbler are the predominating varieties grown. Planting begins about April 1.

NORTH DAKOTA

North Dakota potato farmers grow only early or medium-early varieties: Triumph, Irish Cobbler, Early Ohio, and Chippewa. Production is largely confined to counties in the Red River Valley and to local districts across the northern third of the State. Planting dates range from the first week in May to the first week in June, but the bulk of the planting occurs during the third week in May.

OHIO

No large production centers occur in Ohio, and no county has more than 10 percent of its cultivated land cropped to potatoes.

Irish Cobbler is the predominant commercial variety in the State. The northern limit of commercial production of Irish Cobblers is a narrow belt along Lake Erie. A few years ago Russet Rural was the leading late variety, but it is being superseded by Katahdin, Chippewa, and Sebago.

Temperature largely determines the planting dates in Ohio. In the extreme southern end of the State the average date of planting is March 20; in the central part, April 15; and in the Lake Erie district, April 20.

PENNSYLVANIA

The three leading counties in potato production in Pennsylvania are Lehigh, Lancaster, and Somerset, with seed production chiefly in Potter County. Comparatively few early potatoes are grown, chiefly in the southeastern part. Planting is done as early as possible, usually about April 1 to 10. The late crop in northern Pennsylvania is planted from June 1 to 15; in central, May 15 to June 1; and in

southeastern, May 1 to 15. According to the latest report, 54 percent of the potatoes grown in Pennsylvania are Rurals; 5 percent, Green Mountain; 10 percent, Irish Cobbler; 5 percent, Chippewa; 20 percent, Katahdin; and 6 percent, miscellaneous varieties.

RHODE ISLAND

Rhode Island has a favorable climate for growing potatoes, and a number of soil types found in the State are especially suited to the crop. The markets are close at hand. Rhode Island, however, produces only one-third of the potatoes consumed in the State.

Irish Cobbler is the principal early variety and Green Mountain the principal late one, and they contribute about 33 and 50 percent, respectively, of the potato acreage. Katahdin and Sebago are increasing in production.

Planting begins late in March and extends to May, depending on the location and the season.

SOUTH DAKOTA

Commercial potato production in South Dakota is largely restricted to five counties in the east-central part of the State. Production is divided between certified seed and table stock. Seed stock is largely sold to growers in the Southern States. Table stock is seldom large enough to meet local demands.

Early varieties are planted with few exceptions. Triumph and Early Ohio lead all other varieties. Chippewa and Katahdin are gaining in favor with some growers.

Planting dates vary from the middle of April in the southern part of the State to early May in the northern part. Because of high summer temperatures and frequently poor distribution of rainfall during July and August, late planting of potatoes is not advisable.

VERMONT

The Green Mountain variety predominates and constitutes about 75 percent of the total potato acreage of the State. Up to the last 3 or 4 years Irish Cobbler made up about one-third of the total acreage of certified seed. The quantity of this variety, both certified and table stock, is now very small. Katahdin and Houma are grown to some extent.

WEST VIRGINIA

In West Virginia there are no intensified potato-growing districts. The bulk of the acreage is scattered in districts where growing conditions are particularly suitable. Preston, Tucker, Randolph, Nicholas, and Pocahontas Counties produce most of the main-crop potatoes.

Irish Cobbler, which makes up the bulk of the early crop, is grown in the Ohio and Kanawha River Valleys. Planting is usually done in early March. Some Irish Cobblers, as a second crop, and the late or main-crop potatoes, consisting of both Rural New Yorker No. 2 and Russet Rural, are grown in the intermediate and higher altitudes. The planting dates range from April 15 to June 1.

WISCONSIN

In Wisconsin there are three main-crop potato production districts: (1) Southeastern Wisconsin, including the Racine-Milwaukee district, where the principal varieties grown are Irish Cobbler, Katahdin, Chippewa, and Russet Rural. Most of the planting is done in May. (2) Central Wisconsin, where Irish Cobbler is the principal early variety and Russet Rural and Katahdin the principal late ones. The early varieties are planted in May and the late varieties about June 15 to 30. (3) Northern Wisconsin, where the early varieties are Irish Cobbler and Triumph; late varieties, Katahdin, Chippewa, and, to a much lesser extent, Green Mountain. Recently the Sebago has been recommended by the Wisconsin Agricultural Experiment Station as a promising late variety. Early and late varieties are planted in late May and early June.

U. S. GOVERNMENT PRINTING OFFICE: 1944

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 10 cents